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ABSTRACT

This report on the results of the application of the Health Services Mobility Study (HSMS) task analysis method in diagnostic radiology describes several career ladders starting from the aide level in quality assurance or patient care, rising to the technician level, and then on to the radiologic technologist level, with options to continue to supervision or to radiation physicist. A new job, quality assurance technician, is identified. The volume describes the method and results, the economic rationales for job restructuring, and the use of job ladders; it tells how to rationally restructure jobs after evaluating the allocation of tasks by level and content. It describes a career ladder program, cost strategies, trainee selection, and offers a mini-manual for performance evaluation using HSMS task data. It describes the components of a safe practice and quality assurance program, and includes a check list for the consumer. There are five technical appendixes. (Volume II, available separately, deals with curriculum objectives based on the task descriptions.) (Author/BL)

# USING TASK DATA IN DIAGNOSTIC RADIOLOGY

Research Report No. 8

Volume 1

## JOB LADDERS: ASSIGNING TASKS TO JOBS

by

Eleanor Gilpatrick, Director
Health Services Mobility Study



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I would like to thank the staff members of the Health Services Mobility Study who carefully scaled the tasks for the skills and knowledges required and then reviewed the scaling again and again for consistency. These staff members were Christina Gullion, Senior Research Associate, and Jeanne Bertelle and Irene Seifer, Senior Job Analysts.

The computer work was carried out by Christina Gullion, who also conferred on much of the analysis for Volume 1. Irene Seifer provided editorial inputs. The demanding job of typing this document was carried out by James Green and Rick Preston.

Special notes of thanks go to Dr. Michael R. McGarvey, Vice President for Health Affairs at Hunter College, City University of New York, and William Throckmorton, our Project Officer at the Department of Labor. Without the continued understanding, faith, and support of these two, the work would not have been able to be completed.

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Eleanor Gilpatrick

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# PREFACE

The Health Services Mobility Study (HSMS) has been involved in research in the health manpower field in the United States since 1967. It has designed methods to analyze jobs, create job ladders, develop curriculum objectives, and evaluate job performance. HSMS is sponsored by City University of New York (CUNY) through the Research Foundation and the Hunter College School of Health Sciences. Since 1967, funding for HSMS has come from the Office of Economic Opportunity, the Health Services and Mental Health Administration and the Bureau of Health Manpower, both of HEW, and, primarily, the U. S. Department of Labor, Manpower Administration, now the Employment and Training Administration. The Director of the Project, Eleanor Gilpatrick, holds the rank of Associate Professor at the Hunter College School of Health Sciences, City University of New York.

This report presents the results of task analysis in the area of diagnostic radiology, and is the first application of the HSMS task analysis and curriculum design method to an entire functional area. This work is reported as follows:

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|---|---|
| Research Rpt. No. 8 | USING TASK DATA IN DIAGNOSTIC RADIOLOGY |
| Vol. 1 | Job Ladders: Assigning Tasks to Jobs. |
| Vol. 2 | Curriculum Objectives for Radiologic Technology. |

These volumes make use of and refer to the tasks presented in Research Report No. 7 (see below). Therefore, when the tasks are discussed, only the abbreviated names of the tasks and their code numbers are used.

Volume 1 shows how the tasks of Research Report No. 7 interrelate by content and level of difficulty, and recommends several job ladders and new job structures. The volume tells the hospital administrator how to use the data for assigning tasks to job titles, suggests career ladders, and shows how to use the data for performance evaluation. There is a chapter which outlines a safe practice and quality assurance program for an institution. (It was originally intended as a separate document and was so described in the Preface to Research Report No. 7.)

Volume 2 presents curriculum guidelines and behavioral curriculum objectives for use in educational programs for the radiologic technologist, including suggestions for educational ladders to parallel job ladders. Research Report No. 7 serves as instructional material in connection with this volume.

Research Rpt. No. 7

TASK DESCRIPTIONS IN DIAGNOSTIC RADIOLOGY

Vol. 1 Medical Tasks: What the Radiologist Does.

Vol. 2 Radiologic Technologist Tasks Dealing With Patient Procedures.

Vol. 3 Machine-Related, Patient Care and Administrative Tasks: What Radiologists, Technologists, Nurses, and Physicists Do To Run Things and Look After Patients and Equipment.

Vol. 4 Index of Tasks by Code Number and Extended Name.

These four volumes are the "core" documents, i.e., they present approved "normative" task descriptions in diagnostic radiology. The first three volumes present the task descriptions in a given area in numerical order by code number. Each document describes how the tasks were developed and how to read them. Each also includes listings that arrange the tasks by specialty or function. The task descriptions provide instructional materials in connection with educational programs and/or evaluation or review programs.

Volume 4 lists the extended names of all the tasks contained in the first three volumes in numerical order by task code number and cites the volume in which each task description appears.

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## FOREWORD

The Bureau of Radiological Health of the Food and Drug Administration is responsible for minimizing unnecessary exposure of the population to radiation, including that used in medicine. The Bureau's programs include activities to improve the education of health care personnel in the safe use of radiation. This is important because adequate education of professional and ancillary personnel who prescribe, conduct or interpret radiologic examinations is a crucial determinant in assuring optimum medical care with minimum radiation exposure.

The educational process in the medical radiation area, as in any field, can be most effective when it is based upon the actual tasks and responsibilities which individuals will be called upon to undertake in practice. Systematically and comprehensively identifying and describing those tasks is thus an important prerequisite in designing effective curricula and credentialing tools. The type of research which is represented by the series of projects entitled "Task-Descriptions in Diagnostic Radiology," conducted by the Health Services Mobility Study, can be an important step in this direction. These particular projects, culminating in several individual reports, contain task descriptions and curriculum objectives of remarkable depth and scope, including much material on protecting patients against unnecessary radiation exposure.

Although the Bureau of Radiological Health has not contributed to the design of these projects or to the content of the reports, we hope that they can serve as a useful resource for those responsible for designing basic and continuing educational programs for medical radiation users, and thus that they can contribute to the safe and effective use of radiation in medical diagnosis.

Mark Barnett
Associate Director
Division of Training & Medical Applications
Bureau of Radiological Health
Food and Drug Administration

# CHAPTER 1.

# ABOUT THIS REPORT

## INTRODUCTION

Research Report No. 8 is the product of the first full-scale application of the job ladder and curriculum design method of the Health Services Mobility Study (HSMS) to an entire functional area. We have analyzed all the work found in a department of diagnostic radiology using the HSMS task analysis method. This report presents recommendations on several career ladders that can take individuals from entry level jobs to professional level occupations. Volume 2 presents curriculum guidelines for educational ladders to parallel the career ladder recommendations. The volume offers behaviorally stated curriculum objectives arranged in sequences that reflect the job sequences we recommend.

## STRUCTURE OF THIS REPORT

Volume 1 of this report presents the results of the HSMS job analysis method in diagnostic radiology. Chapter 1 presents a summary of the results and describes the background of the work and the data base. Chapter 2 presents the results of the analysis, i.e., our job structure and career ladder recommendations. Chapter 3 is directed to the hospital or department administrator. It suggests how the data and results can be used by an individual institution or department to make rational use of manpower. It suggests how to restructure jobs and assign tasks to jobs and titles at various levels to provide upward mobility while enhancing the quality of output and holding costs down. Chapter 3 also describes how to use the HSMS data for performance evaluation. Chapter 4 deals with

safe practice and quality assurance. It offers a program for quality assurance and a check list for consumers. It is directed to the institution, educator, or consumer interested in the promotion of radiation safety and quality care. Chapter 5 covers the technical content of the HSMS method, and describes the analytic work.

Volume 2 of this report presents curriculum guidelines for educational programs that would parallel the career ladders. The HSMS method of curriculum design has been applied to the aide, technician, and technologist levels in diagnostic radiology. The results are guidelines for educational ladders and sets of behavioral curriculum objectives which utilize the HSMS task data. Chapter 6 describes the concepts used and the work that was done.[1] Chapter 7 presents the curriculum guidelines, including suggestions for program design, instruction, and the use of curriculum objectives in the development of proficiency tests. Chapter 8 presents curriculum outlines, and Chapter 9 presents the curriculum objectives in numerical order.

The task descriptions, which are the core of the analysis, are voluminous. The descriptions are detailed, and can serve as instructional materials. They can also be used for developing in-house programs in performance evaluation, quality assurance, or trainee selection for upgrading. Our decision was to present the task descriptions in a separate report, Research Report No. 7, which is in four volumes.[2] It presents the HSMS

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[1] The chapters are numbered consecutively in the report; Chapter 6 is the first chapter of Volume 2.

[2] Gilpatrick, Eleanor, Task Descriptions in Diagnostic Radiology (four volumes), Research Report No. 7, New York: Health Services Mobility Study, 1976.

task descriptions which are the reference base of this report. (See the preface for a description of the volumes.) In this report the tasks are referred to solely by their abbreviated task names and/or by code number.

We wish to keep the text of this report as unencumbered as possible. Therefore, a good deal of the detailed statistical material is provided in the five appendixes at the end of Volume 1 of [redacted]ort.

Appendix A lists, by order of Task Code Number, the abbreviated names of all the tasks that were used in the analysis. There are 560 tasks represented, of which 368 were identified in diagnostic radiology. The remainder were found solely in an earlier pilot test of the HSMS method that was carried out in an ambulatory care, family health center.[3] (Some of the analysis involved pooling all the task data developed by HSMS.) The end of Appendix A identifies the tasks used for each of the separate analyses (computer "runs"). The appendix also indicates the volume in Research Report No. 7 in which a task's full description appears.

The basic data for the analysis are the HSMS skill and knowledge category scale values assigned to each of the tasks. The scale values for each task reflect what an individual must know in order to perform the task. Appendix B lists each of the skill and knowledge categories identified for any of the 560 tasks. Since we utilized three selective computer "runs" in addition to the one containing all 560 tasks, and since some of

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[3] The results of the pilot test are reported in:
Gilpatrick, Eleanor, Suggestions For Job and Curriculum Ladders in Health Center Ambulatory Care: A Pilot Test of the Health Services Mobility Study Methodology, Research Reports Nos. 4 and 5, New York: Health Services Mobility Study, 1972.

the analysis (the factor analysis) uses only skill and knowledge categories that have some degree of frequency across tasks, the appendix also provides the reader with information on which skill and knowledge categories were used in each "run" and for factor analysis. (The factor analysis is described in Chapter 5.)

The scales used for rating the tasks on their skill and knowledge requirements are presented in Appendix C. There are sixteen skill scales and a knowledge scale that is used with all the knowledge categories. A task frequency scale is also provided for use by administrators. (It was not used in the analysis of the data.)

Appendix D is presented for readers interested in the details of the factor analysis. It presents the factor solutions which we adopted, the loadings of skill and knowledge variables on the "variable factors" (Table D.1), and presents the assignment of tasks to the various "task factors" (Table D.2).

Appendix E contains the heart of the job analysis results. It contains seven tables, each one representing a task factor (grouping). The tasks assigned to each factor are listed in descending order of difficulty within job levels.[4] The tables also present the loadings of the tasks on their factors. The first four of the tables in Appendix E are the basis for the HSMS job structure and career ladder recommendations. The task groups in these tables at job levels 1 (aide), 2 (technician), and 3 (technologist)

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[4] The three tables dealing with radiologist tasks list the tasks in descending order of their factor loadings. This is not necessarily the same as difficulty.

are the reference groupings for which the curriculum objectives are designed, and provide the basis for the educational ladder sequences. Therefore, the appendix serves both Volume 1 and Volume 2.

## SUMMARY OF RESULTS

1. The first full-scale application of the HSMS job analysis method has been successfully completed in diagnostic radiology. The analytic techniques have produced distinct, logical groupings of tasks into interrelated family groupings (factors). Within these we have been able to assign tasks to job levels. As a result, we suggest several new job structures and career ladder progressions.

2. One career ladder starts at the entry (aide) level, deals with materials and equipment, proceeds to a technician level in quality assurance, and then enters the radiologic technologist level, with options to continue into supervision and education or to branch out and upwards towards the job of radiation physicist.

3. A new job, that of qualtiy assurance technician, has been identified. It could be developed at institutions large enough to support this specialty. The job provides an upward step for the aide in radiologic technology. It is a job from which to move on to radiologic technology patient examination procedures.

4. The role of the radiation physicist in diagnostic radiology is distinguished from that of the quality assurance technician. The former is defined here as a truly professional-level occupation, that of planning and running quality assurance programs.

5. A second career ladder starts at the entry (aide) level, deals with patient-oriented activities, proceeds to a technician level in patient care, and then enters the radiologic technologist level, with options to continue into supervision and education or to branch out and upwards toward specialized nursing or emergency patient care.

6. The job for the patient care technician is narrower in scope than the full range of nursing that is associated with practical nurse or registered nurse programs. The overlap of training could be acknowledged for individuals wishing to move up in the nursing field. This job provides an upward step for the aide in contact with patients in diagnostic radiology. It serves as a job from which to move on to radiologic technology patient examination procedures.

7. The basic structure of the radiologic technologist's patient examination tasks combines a good many patient care skills and knowledge, quality assurance (technical) skills and knowledge, and major portions of anatomy and physiology. Thus, either or both of the two job ladder sequences are possible, but require differently sequenced curriculum components. These are provided in Volume 2.

8. We were able to successfully apply the HSMS method of curriculum development to produce curriculum objectives that cover all the work at the aide, technician, and technologist levels in diagnostic radiology. These can be arranged in curricula for five different jobs, a single job, or any combination of these.

9. We present curriculum sequences (outlines) for the radiologic technologist which allow individuals to opt to exit during the programs as fully qualified aides or technicians in either patient care or quality assurance. These educational ladders parallel the career ladder recommendations mentioned above.

10. The curriculum objectives are presented in units that can be arranged in any sequence. These can parallel job sequences or can be arranged across jobs to provide sequences that solely reflect rising levels of difficulty, or any combination of these. All the curriculum objectives are geared to the clinical performance of the tasks identified.

## BACKGROUND

This section briefly reviews the objectives of the HSMS task analysis method, describes the coverage and data base, and touches on the task, skill, and knowledge components of the method.

### Objectives

Two of the major goals of the HSMS task analysis method are the design of job ladders and the development of curricula for educational ladders to parallel the job ladders. Our intent is to assign tasks to groupings that require related skills and knowledges, and assign the tasks within each grouping to job levels. The tasks within each job level in a

given grouping would require similar levels of the skills and knowledges that characterize the group. (Later in this report we will call the groupings "factors," since the groupings are arrived at through factor analysis.)

For HSMS, a job ladder is a logical progression from one job level to another within an interrelated grouping of tasks. Designed in this way, an individual's training for and experience in a lower-level job on a ladder is preparation for the next level on the ladder, and the additional training and education needed for the next step on the ladder is kept to a minimum. If the progression up the ladder can reach to professional levels it is legitimate to call the job ladder a career ladder.

The HSMS method makes it possible to analyze tasks in terms of skill and knowledge requirements, groupings, and levels. From the point of view of management, this kind of analysis makes it possible to assign work duties to job titles rationally, to make optimum use of more highly trained and more expensive employees, and, at the same time, to have all the work carried out by staff who are properly trained to provide quality output. It makes little economic sense to assign low-level tasks to high-level personnel; it makes little social sense to assign high-level tasks to staff improperly trained to carry them out.

From the point of view of employees, the design of job ladders means that there is an opportunity to move ahead within the institution; the individual's investment in current training becomes an investment in the future. Success in the given job means mastery of skills and knowledges that will also be needed at higher levels; and future training can

be expected to require related skills and knowledges, and/or higher levels of skills and knowledges already familiar in the current work. The next step up is also likely to be observable to the employee while he or she is operating in the current job. The next step is not a mystery.

From the point of view of society, the job ladder means that employees can be trained to reach their maximum potential and can also have socially useful, income-producing jobs along the way that reinforce their training. Each rung on the ladder is an interim option to work; but continuing education or later reentry to a program to continue up the ladder are also options. The work and training are not mutually exclusive; employees can support themselves and institutions can have the benefit of their training at one level while they are in preparation to move up to the next level on the ladder; the current work can only benefit from this.

The HSMS analytic approach also makes it possible to uncover lattice relationships among task groupings. While groups of tasks often have mutually exclusive skill and knowledge requirements, some groupings have a great deal of overlap. Especially at the early stages, where the investment in specialized training is not great, our interest is to discover cross-over possibilities. A lateral movement is possible from job to job at points where some of the training investment is still applicable, but where a change in the direction of the upward movement from one set of skills and knowledges to another is also possible.

While the social investment in health services lies primarily in the education and training of health manpower, one finds workers in health service occupations locked into dead-end jobs. At the same time, shortages exist for properly trained professional and skilled personnel. One also finds shortages of educational facilities while schools continue to require redundant training. In the face of rising costs and the demand for quality patient care, improper allocation of functions to personnel, redundancy of training requirements, and non-transferability of much lower-level training create an indefensible waste. We hope that this report will be useful in the elimination of such waste. We also hope that our attention to and concern with the quality of performance (as reflected in our tasks and in our skill and knowledge scaling) will result in improved patient care.

Coverage

The 368 tasks described in Research Report No. 7 are our basic units of analysis. The skill and knowledge requirements for the tasks are the data base for this report. We attempted to cover all the tasks that one would be likely to encounter in a department of diagnostic radiology in a major hospital center, including those that would be found if full-scale quality assurance programs were part of the operations of the department.[5] Some specialized types of examinations are excluded, as well as some procedures considered to be dangerous by our expert reviewers. On the whole, however, the 368 tasks are probably more than the number that

[5] Each volume of Research Report No. 7 describes in greater detail the particular coverage of the tasks in that volume.

would be found in any given general hospital.

The HSMS collection of task descriptions is not like a sample survey. Sample surveys would cover only selected work and would pick up the same work at many locations. We deal with a given task unit only once. Our intention is to describe and represent approved work procedures for the purposes of developing instructional materials, curriculum objectives, and career ladders. For such purposes we described, not just the most typical tasks, we covered important rare or difficult procedures, emergencies, contingencies, and the best possible practice. The data are normative and descriptive. Unlike the case with predictive analysis, which deals with probability theory and requires sampling of the "universe" being studied, we attempt to present the universe and describe its characteristics.

Every effort was made to include every procedure carried out by radiologists, radiologic technologists, the body of tasks which describe work with diagnostic x-ray equipment for the purpose of preventive maintenance, quality assurance and radiation protection, and such areas as first aid, record keeping, film processing, administration, nursing, housekeeping, and preparation of materials. We include some very new procedures involving computerized transverse axial tomography, ECG monitoring in the angiography room, and application of manual pressure and pressure dressings after percutaneous catheterization.

All the task descriptions incorporate material from professional literature and critical review by experts. However, the starting

point was interviews with actual "performers" in the field. Most of the field interviews were carried out by HSMS teams of job analysts at Montefiore Hospital and Medical Center in New York City over the period August, 1972 to mid 1976. Montefiore Hospital is a respected major voluntary hospital. Field interviews dealing with obstetrics and gynecology were collected at Mt. Sinai Hospital and Medical Center in New York City, another highly regarded voluntary hospital. Alternative procedures and those not carried out at the hospitals where we conducted interviews were described based on our use of the literature and the inputs of our reviewers.

Research Report No. 7 completely bypassed the issue of assigning tasks to job titles; we simply presented the tasks. There is little uniformity with respect to the job titles used by personnel departments in hospitals. The technician in the hospital is the technologist of the professional association. The senior technologist in a large institution can be so designated because there is scope for a division of labor. However, the assigment of tasks to senior and junior titles may not always represent an arrangement reflecting the level of task difficulty involved. Further, in some states only a registered nurse can give a patient an injection subcutaneously or intramuscularly, while, in others, the radiologic technologist can carry out most nursing functions. Currently, quality assurance tasks can be found in many different job titles and at many job levels.

Our decision with regard to title was to identify the universe of tasks, to rate the tasks for their skill and knowledge requirements,

and to await the analysis before we talked about levels or titles. Table 1 indicates our approach to level and title in this report. The right-hand side of the table presents a cross-section of titles likely to be encountered in the field. On the left-hand side we designate the approximate level involved using a rough functional and academic scale. These levels do not of themselves serve as job titles, because the selection of job titles will always be the province of the employing institution. However, we try to maintain a consistent usage in this report.

The aide will always be an entry-level designation; the technician will always connote education of lesser duration, depth, and breadth of detail than that of the technologist; and the professional will always imply at least four years of academic and/or specialized education. Later in this report the "titles" which we use in presenting the career ladders employ words such as aide, technician, or technologist to designate level, and qualitative terms to designate task content. We make no case for any particular title.

The lower half of Table 1 includes the job titles which we covered in our ambulatory care pilot test. The 273 tasks we described were not as fully developed as those for diagnostic radiology, and were not meant to be "normative" tasks. However, we decided to do some of our analysis with a combined set of tasks in order to compare the groupings obtained in the larger, combined set with the 368 found in diagnostic radiology.

Table 1. JOB TITLES COVERED IN DIAGNOSTIC RADIOLOGY TASK ANALYSIS



| Job Level, as Used in HSMS Report | Types of Job Titles Found in Institutions |
|---|---|
| 8. Specialized Advanced Professional | Attending radiologist; neuroradiologist; pediatric radiologist; angiographer; diagnostic radiologist; titles by various other radiology specialties. |
| 7. Advanced Professional | Senior radiology resident (interviewed by HSMS only to pick up tasks not carried out in any other title). |
| 5. Professional | Radiation physicist; physicist; senior physicist; health physicist; radiological physicist; medical physicist; radiation safety officer; staff physicist; consulting physicist; radiologic engineer. |
| 4. Junior Professional; Supervisor | Chief radiologic technologist; assistant chief technologist; head nurse; supervisor of technologists, technicians, and/or nursing personnel and aides. |
| 3. Technologist | Radiologic technologist; x-ray technician; lead or senior x-ray technician; contrast study technologist; pediatric x-ray technologist; angiography x-ray technician; quality control x-ray technologist; radiographer; registered nurse. |
| 2. Technician | X-ray technician; junior x-ray technician; junior physicist; licensed practical nurse; EKG technician in angiography suite. |
| 1. Aide | Darkroom aide; nurse aide; housekeeping aide; EKG technician; medical assistant; clerk; attendant; messenger. |
| | Not covered: secretary; department administrater; chief radiologist; jobs at level 6. |
| | **Titles Covered in Ambulatory Care Pilot Test** |
| 8. Specialized Advanced Professional | Internist; obstetrician-gynecologist; pediatrician; radiologist. |
| 5. Professional | Nurse practitioner. |
| 4. Jr. Prof.; Supervisor | Lead x-ray technician. |
| 3. Technologist | X-ray technician. |
| 2. Technician | Family health worker; LPN. |
| 1. Aide | EKG technician; medical assistant; darkroom aide. |

## ANALYTIC COMPONENTS

The HSMS method of job analysis begins with task analysis. The HSMS definition of task conceives of the task as a work activity unit in which the "performer" combines existing technology, knowledge, materials, and equipment with skills to produce units of output. The HSMS definition of task is designed to result in the identification of a unit of work which can be moved from one job to another without disrupting other activities. The task is a unit of work which is conceptually smaller than a job as a whole, but is large enough to have an identifiable, usable output. The HSMS task definition is as follows:

> A task is a series or set of work activities (elements) that are needed to produce an identifiable output that can be independently consumed or used, or that can be used as an input in a further stage of production, by an individual who may or may not be the performer of the task.[6]

Once identified, a task has a code number, an abbreviated name, an extended name, and a full task description. The task descriptions present the task procedures in a logical sequence, including a good deal of detail. The extended task name is a summary of the essential task steps, and the abbreviated task name is used for inventory purposes, such as in Appendixes A and E. The task code number assigned to the task uniquely stands for the contents of the task and covers the task's output, what is used, the kind of recipient or respondent dealt with, and how the task is done. Regardless of the job title, institution, or industry in which the

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[6] In order to facilitate use of the definition, the HSMS method includes a set of definitional rules. These are presented in the first chapter of each of the volumes of Research Report No. 7 and in other HSMS reports.

task is found, it will always have the same code number. The number itself has no intrinsic meaning.

Skills, Knowledge Categories and Scaling

The HSMS method was designed as a system. With the job ladder and educational ladder objectives paramount, we devised a set of skill scales, a knowledge classification system, and a knowledge scale that could be used in any context.[7] As a result, there is a consistent, underlying taxonomy that makes it possible to compare skill and knowledge requirements for one task with those of any other task.

The skills and knowledge categories have the property of being learnable (unlike aptitudes), so that all the information on tasks which we collect can be translated into curricula.

The categories found in the Knowledge Classification System are arranged in outline form, with eight-digit code designations which reflect a category's degree of indentation in the outline. Each category appears in only one location in the system, even if it is appropriate in more than one part of the outline.

The HSMS analysts scale each task on each of the skill scales; they identify the HSMS Knowledge Classification System categories needed

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[7] The scales are presented in Appendix C. The knowledge categories identified for the 560 tasks included in the analysis are presented in Appendix B. For a full presentation of the HSMS method see:
Gilpatrick, Eleanor, The Health Services Mobility Study Method of Task Analysis and Curriculum Design (four volumes; Volume 4 by Eleanor Gilpatrick and Christina Gullion), Research Report No. 11, New York: Health Services Mobility Study, 1977.

to perform each task, and assign a scale value to each category using the HSMS knowledge scale. This process includes interviews with performers in the field. When the analysts are sure of their scaling, they prepare forms which indicate, not only the scale values for skills and knowledges for each task, but the specific part of each task, i.e., task language, to which a given scale value refers. This process ensures careful, reliable, and valid work on the part of the analysts, relevant data, and provides an input to curriculum design.

The skill and knowledge data go through an in-house check to ensure that the scales are being applied consistently and appropriately. Teams review each others' work, and a senior staff member reviews all the work, comparing similar or related tasks to one another.

The HSMS scales were developed with the use of a statistical process known as Thurstone Scaling or equal appearing intervals. As a result, the scales have the characteristics which permit them to be treated as statistical variables. It is the scale values of each task on the skill and knowledge variables that are the inputs to the statistical analysis.

For a given set of tasks, there will be scale value data on 16 skill variables and the number of knowledge category variables equal to the number of categories identified for the entire set of tasks. Each task is represented once and only once in the analysis. A description of what we do with the data and the decisions we came to in diagnostic radiology is presented in Chapter 5.

# CHAPTER 2

## JOB STRUCTURES AND CAREER LADDERS FOR DIAGNOSTIC RADIOLOGY

This chapter discusses the HSMS analysis of the task data in diagnostic radiology and presents the results: our job structure and job/career ladder recommendations. The reader who wishes to understand how we arrived at the results is invited to read Chapter 5 at this time. However, the general reader is more likely to be interested first in our recommendations. This chapter can be read without Chapter 5 if the following simple definitions are remembered:

1. Each skill and each knowledge category is a scaled variable. Tasks are rated for the skill and/or knowledge scale values required for their performance. These scale values are our task data.

2. The word factor means grouping. Task factors are groupings of tasks that are interrelated.

3. The way skills and knowledge categories group together in factors determines the way tasks can be grouped together in factors.

4. We assign names to a factor to describe the skill, knowledge, and work context of the tasks in the factor.

5. The assignment of tasks to job levels means arranging tasks in a factor (group) so that tasks which require similar skills and knowledges at similar scale values are assigned to corresponding and appropriate job levels.

6. In this chapter we refer to the task factors we obtained by number and name as follows:

| | |
|---|---|
| Factor I: | Non-neurologic Radiology |
| Factor II: | Neuroradiology |
| Factor III: | Radiologic Technology |
| Factor IV: | Patient and Emergency Care |
| Factor V: | Obstetrics-Gynecology Radiology |
| Factor VI: | Quality Assurance (in Diagnostic Radiology) |
| Non-factor A: | Administration |

## JOB STRUCTURE RECOMMENDATIONS

### Figure 1: Summary of Recommendations

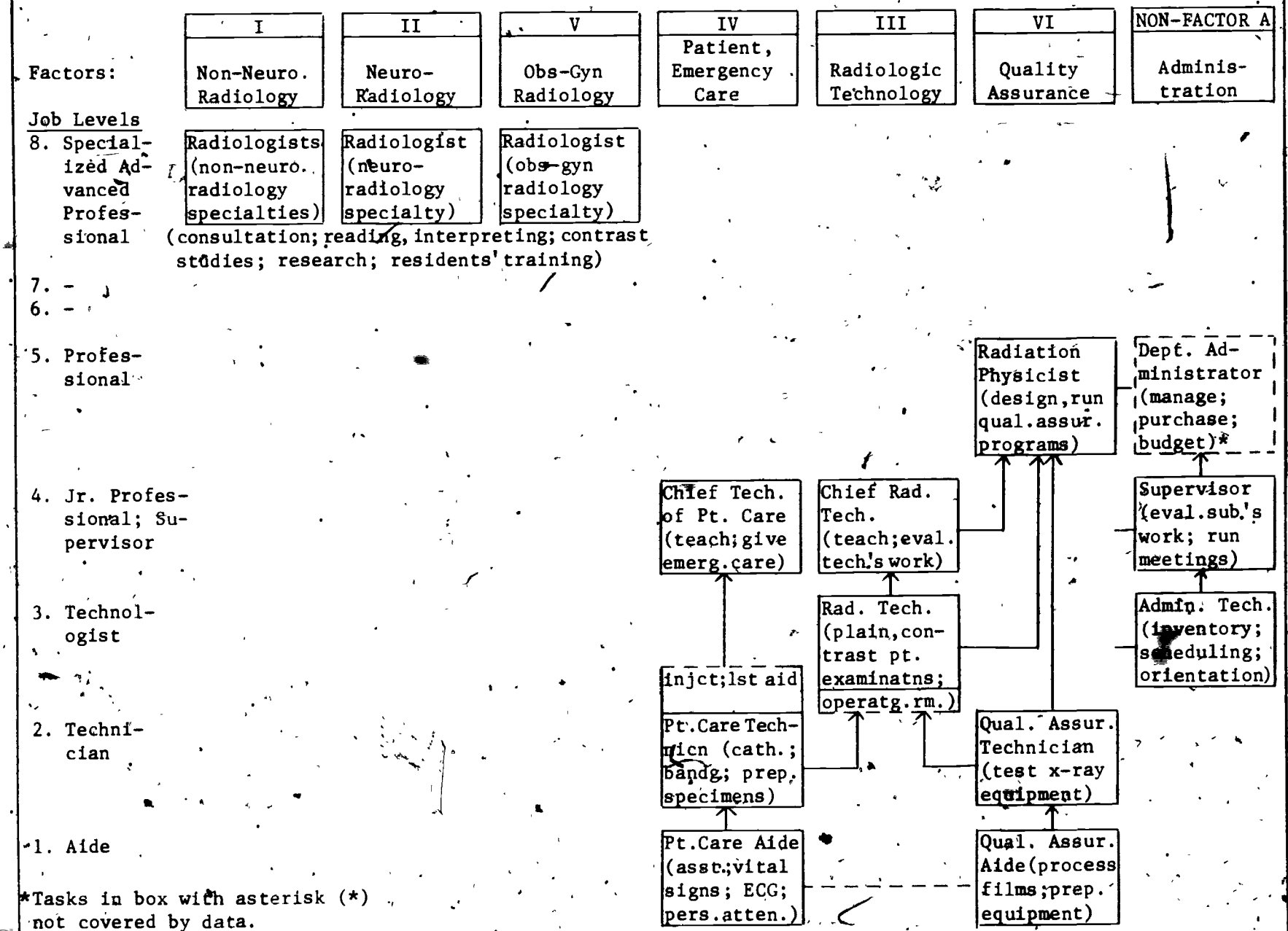
The results of the analysis and our job structure and career ladder recommendations are summarized in Figure 1. This figure shows in graphic form the task factors, the types of tasks assigned to job levels within factors, and the job structures we recommend. The career line and lattice possibilities are indicated. The career lines allow for upward mobility from the aide level to the supervisory or professional level by several different routes. The tables in Appendix E present the tasks in each factor arranged by job levels. Each box in Figure 1 represents the tasks in a given factor at a given job level; thus, the Appendix E tables provide the task content underlying Figure 1.

### Radiologist Jobs

Nothing dramatically new was uncovered with respect to radiologist jobs. Most radiologist tasks appear on three factors which contain only radiologist tasks and no lower-level tasks. Factor I: Non-neurologic Radiology, Factor II: Neuroradiology, and Factor V: Obstetrics-Gynecology Radiology were the major divisions we found, even though, in actual practice, radiologists have more specialties than these. The specialization follows overall training in radiology during residency.

Of greater significance is the fact that we found no justification for anything like a "radiologist's assistant" below the physician level and above the radiologic technologist level. (There have been suggestions that radiologists' assistants could or should carry out fluoroscopy for areas of the body such as the gastrointestinal tract.)

Figure 1. SUMMARY OF FACTOR STRUCTURE OF TASKS BY JOB LEVEL: DIAGNOSTIC RADIOLOGY CAREER LINES




*Tasks in box with asterisk (*) not covered by data.

Note: For task content see Appendix E.

We object to the creation of a radiologist's assistant job because our analysis indicates that a very large number of knowledge categories are needed at high scale values for all the tasks in the three radiologist factors. The sheer quantity of knowledges needed is the reason we obtained separate radiologist factors. If the radiologist's assistant were assigned any of these tasks, even in a narrow specialty area, we are concerned that the required educational preparation would be lacking. Radiologists make critical evaluative and diagnostic decisions about dynamic functioning while they are conducting fluoroscopy. This requires knowledge, not only of an organ of the body, but of a series of interrelationships with other systems of the body, normal structure and function, development, and pathology. Mastery of these areas would appear to require something like the training found in medical school, internship, and residency.

If the radiologist's assistant were assigned to carry out fluoroscopy for an area such as the gastrointestinal tract, he or she would be compelled to approach the work with a limited orientation and background, even if additional training were provided. In the opinion of this author, it is preferable not to encourage further fragmentation of diagnostic knowledge. For diagnostic purposes we need medical professionals prepared to see the patient holistically, as a functioning, interrelated entity, and not a set of separate organs. The only way to test this thesis is to compare the results when a radiologist conducts the examination with the results from a radiologist's assistant and assess the implications from the point of view of the patients' well-being.

On the other hand, we found, as we had in our pilot test, that there are physical care or treatment tasks which physicians do, that by

virtue of the narrow range of knowledge categories and the manual skills involved, might be done better by a specialist below the physician level. The specialist would be practicing the skills more frequently; the content could be mastered in a career line progression.

We found four such tasks in diagnostic radiology. We found them being done by radiologists or residents, but they actually show up at various levels in the patient care factor. We see real justification in removing these tasks from radiologist jobs and assigning them to their appropriate factor and job level. The tasks are: providing emergency care (above the level of providing first aid; Task 77); administering the intravenous test for allergy to contrast media (Task 19), catheterizing the male (as well as female) urethra (Task 181), and preparing specimens such as washings, cell, or tissue biopsies for transportation to the laboratory (Task 65).

Quality Assurance: The Physicist, The Technician, and The Aide

The growing interest in patient and staff safety in diagnostic radiology has been given expression in a new professional specialty which finds physicists employed by hospitals as staff members or consultants. Hospitals need such experts to plan, set up, and maintain safe installations. They need programs in equipment testing, film processor monitoring, and patient and staff radiation monitoring. They need a system to guarantee that diagnostic-quality radiographs are produced with minimum exposure to patients and staff. These concerns and needs are underlined in recent legislative requirements concerning equipment standards. The need to check periodically that equipment meets those standards is now mandated.

We call this entire area quality assurance. Our task analysis results suggest that jobs could exist in this factor at three separate levels.

The radiation physicist in diagnostic radiology (at level 5) is needed to design and run radiation protection and quality assurance programs, to advise on equipment and installations, and to teach quality assurance procedures and the need for them. This job is represented in Figure 1 at level 5 in the quality assurance factor. Its central tasks are presented in Appendix E, Table E.1.

We estimate that the radiation physicist in diagnostic radiology quality assurance is at level 5. This is lower than would be the case if we considered that preparation for the job requires preparation in a classical Ph.D. physicist program. On the contrary, we see this job coming at the end of a career ladder where required new subjects are added to those already mastered for the technical aspects of radiologic technology at the technologist level, and/or for quality assurance at the technician level.

Currently, in the real world, the physicist in diagnostic radiology brings to the job his or her own background in a traditional physics program and in a particular physics specialty which will have been selected on the basis of earlier preferences. The physics program will not have contained courses in quality control; the methods for testing x-ray equipment will be selected on the job, and will reflect the physicist's specialty background. The Ph.D. physicist is probably over- and under-qualified for the job we describe here -- over-qualified in that much of the subject matter in the Ph.D. program is irrelevant for the

work -- under-qualified in that quality assurance requires a knowledge of the examinations involved, radiobiology, and some anatomy. We suggest that new curricula that are designed to prepare an individual for this emerging occupation are in order.[1]

Our results suggest a new job, that of the quality assurance technician in diagnostic radiology (at level 2). The tasks of this job involve carrying out the actual equipment tests, patient and staff radiation exposure monitoring, and film processor monitoring as designed by the physicist. These tasks do not require the same educational preparation as designing and running the programs or even carrying out radiologic technology patient examinations. Our task data indicate that a separate job can be created at institutions large enough to support one or more individuals for this function. The number of skill and knowledge categories needed for this job suggests the technician level, and is actually fewer than those needed for the job of radiologic technologist.

The appeal of this job structure for large institutions is that it can minimize costs while maximizing quality. Technicians can do the testing work while physicists are free to carry out higher duties as staff members or consultants. For the physicist this means being relieved of relatively routine work; for the aide who may now be carrying out darkroom or other similar tasks, the technician's job means a step up on the

[1] Table E.1. in Appendix E presents the tasks for the job. Tables 2 and 7 (presented in Volume 2) contain the skill and knowledge categories and scale values for the tasks assigned to the radiation physicist job in Factor VI, at level 5.

job ladder. For the technologist it means concentrating on patient examinations.[2]

The job of quality assurance aide in diagnostic radiology (at level 1) combines tasks which currently cut across diverse job titles. The preparation of procedure trays and emergency carts, for example, can be found in nursing or technologist titles; cleaning examination rooms can be a housekeeping or nurse aide assignment. We combine these tasks with those of film processing, starting up or shutting down equipment, preparing subtraction prints, and even tasks of tallying and handling records. The unifying thread is the need to pay attention to details, to be scrupulously careful about cleanliness, contamination, and accuracy. These tasks truly relate to safety and quality with respect to records, materials, and equipment. They have little to do with direct patient contact; they become direct lead-ins to the job of the quality assurance technician.

We suggest that these tasks contained in level 1 of Factor VI should all be assigned to a separate job title at the aide level, perhaps with rotation of specific groups of assignments. This will make maximum use of the limited body of skills and knowledges needed to carry out any one of the tasks, since most are common to most of the tasks. The diversity of the procedures is a protection against boredom and not a reason against such a job structure.

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[2] Table E.1 in Appendix E presents the tasks allocated to the quality assurance factor. Tables 2, 3 and 4 (in Volume 2) contain the curriculum content needed for the tasks of quality assurance aide, technician, and radiologic technologist.

Patient Care: The Aide, The Technician and Higher [3]

The job of patient care aide is comparable to that of the quality assurance aide. It brings together diverse lower-level activities. In this case each deals directly with the patient. The unifying thread here is the need to treat the patient with dignity, sympathy, and understanding, as well as to give careful attention to the patient's well-being. The factor assigns to the patient care aide preparation for ECG monitoring; monitoring is then picked up at the technician level. Many of the tasks involve the measuring of patient symptoms and functions. This job brings together a variety of tasks which provide interest while at the same time utilizing the relatively narrow set of skills and knowledges common to the tasks in the group.

In Figure 1 we present the patient care technician (at level 2). The job also includes three tasks that might be appropriate for level 3 in patient care.[4] (These tasks are shown in Figure 1 above the demarcation line for a level 2 job.) The tasks assigned to the job of patient care technician are currently being done by registered nurses, radiologic technologists, and/or practical nurses. Grouped at the technician level in this factor, they provide a logical step up for the patient care aide and build on the skills, knowledges, and task experiences at level 1.

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[3] Table E.3 in Appendix E presents the tasks allocated to the patient care factor. Tables 2, 3 and 5 (in Volume 2) contain the curriculum content needed for the tasks of patient care aide, technician, and supervisor.

[4] In Chapter 5 we discuss how to handle these three tasks which do not constitute a large enough number of tasks to warrant being placed at a separate job level.

We suggest that the nursing training offered in the usual RN or LPN program may be broader than is needed in diagnostic radiology; yet such programs may omit tasks such as ECG monitoring or the preparation of specimens for the laboratory, which are included in this job. We suggest that training for this job can be extracted from current LPN or RN programs and supplemented as needed so that reentry with credit to LPN or RN programs is a possible option further along in an individual's career progress.

Level 4 in the patient care factor is essentially a supervisory and teaching function. Such a job would include the level 4 tasks under administration (non-factor A) in Figure 1. However, two of the tasks involve emergency care. This suggests a broader-based nursing specialty in emergency life support. The two tasks do not constitute a separate job; they are indicative that there should be an option into a nursing specialty after reentry to the factor, perhaps at the missing technologist (RN) level.

Radiologic Technology: The Technologist and Higher[5]

Level 3 in radiologic technology is the radiologic technologist. This job as represented in Figure 1 is almost exclusively composed of patient examinations, both plain films and contrast films, in the operating room and at the bedside, in the examination room and in the angiography room. The requirements for these tasks combine much of the patient care content of Factor IV and the technological content of Factor VI with know-

[5] Table E.2 in Appendix E presents the tasks assigned to the radiologic technology factor. Tables 2, 3, 4 and 5 (in Volume 2) contain the curriculum content needed for these tasks.

ledge of anatomy and physiology. Thus, this job is a logical progression for technicians in Factors IV and VI. This progression does not exist in current practice.

In many institutions the radiologic technologist is expected to carry out many of the tasks which we show at the aide and technician levels in patient care and quality assurance. This means that the training of the technologist, which is usually two or more years, covers aide- and technician-level work as well as radiologic technology, and in no particular sequence. Since the technologist is rarely employed until the entire program is completed, the hospital winds up paying technologist wages for aide- and technician-level work. The technologist wastes a good deal of training and is unemployable throughout the training period (except in cases where clinical training involves payment).

In an institution large enough to employ a staff of some size, it would be more sensible to save salary costs and training investments by assigning radiographic examinations to technologists, and by having technicians and aides carry out the other work.

In some large institutions we find the practice of designating the radiologic technologist who does contrast studies as a senior technologist, while plain films are assigned to technologists who do not have a senior rank. Our point score analysis (described in Chapter 5) provides no real justification for this distinction.

In the case of contrast studies, the technologist draws more heavily on knowledge of asepsis and nursing knowledge, but the radiologist

is there to review the radiographs and decide when the diagnostic information is complete. In the case of plain films, the radiologic technologist is more responsible for the decisions on what to do, how to do it, and when the examination is at an end. There is a balance; the order in Table E.2 does not give either contrast studies or plain films greater weight. In the six highest-ranking examinations, computerized transverse axial tomography, conventional tomography, plain films (both pediatric and non-pediatric), and angiograms all appear.

The level 4 function in diagnostic radiology is for the supervisor and educator. The tasks here are probably best combined with the administrative tasks in non-factor A, which are not sufficient to constitute a separate job. Currently the chief technologist is often saddled with an uneconomic allocation of low-level clerical and administrative tasks or the tasks we suggest belong to the quality assurance technician. We suggest that there may be a confusion of the essentialness of administrative or testing functions with the level of those functions.

Administration: The Technologist, The Supervisor and The Department Administrator[6]

The tasks assigned to levels 3 and 4 of non-factor A do not constitute separate jobs. At level 5, the department administrator is a job we know exists but did not study in detail.

The level 3 tasks deal with departmental functioning, such as taking inventories, ordering supplies, and scheduling patients and staff.

[6] Table E.4 in Appendix E presents the administrative tasks. Tables 2, 3, and 6 (in Volume 2) contain the curriculum content needed for the tasks at levels 3 and 4. See Chapter 5 for a description of how non-factor A was constructed.

Level 4 tasks relate to the supervision and evaluation of staff. These tasks should be combined with tasks in other factors at comparable levels.

The department administrator runs the daily functions of the department, coordinates operations, makes major purchasing decisions, or carries them out. We suggest that this job, at level 5, would benefit by being filled by someone who has a broad knowledge of the work of all the staff rather than a detailed knowledge of one or two functions, and by someone who has progressed through the level 3 and 4 administrative tasks of scheduling and supervision. With current emphasis on quality assurance, it is interesting to consider whether the job shouldn't be a lateral movement for the radiation physicist who may have been a radiologic technologist or a quality assurance technician, who already advises radiologists, and who has a taste for administration. Such an individual would be an ideal choice to carry out decisions on the purchase of equipment, and could guarantee that quality assurance standards are maintained in the department.

## CAREER LADDER AND LATTICE RECOMMENDATIONS

### Overview

The HSMS job ladder recommendations are arrangements of jobs in promotional steps derived from the task factors. The jobs in the ladder require interrelated skill and knowledge categories. We also make suggestions on job lattices. Job lattices allow for linkages across ladders both horizontally and diagonally. This provides cross-over options and a choice of promotional pathways. The principle involved is that the skills and knowledges required at a given job level for a factor may serve as a basis for more than one specialty. A given specialty may build on more

than one kind of prior preparation; the entry to specific professional jobs could thus be reached through more than one factor. Conversely, a given job level in a factor can be a step towards more than one specialty.

Figure 2 repeats the career line progressions of Figure 1. These are the logical results of the task analysis and the assignment of tasks to levels within factors.

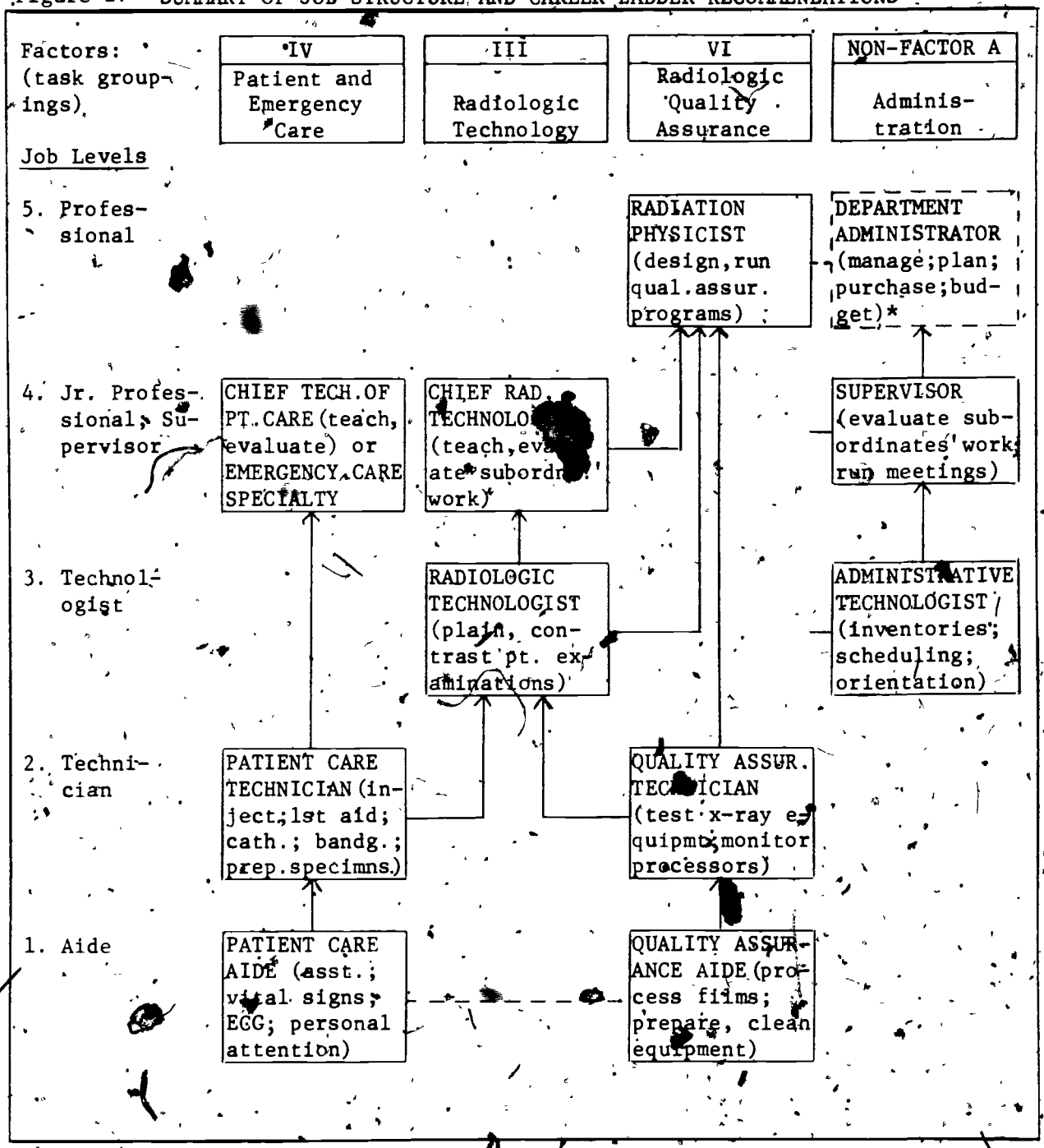
The nature of the skill and knowledge requirements for the radiologic technologist is such that two career lines leading to the radiologic technologist are possible; options to progress further are also provided.

The Job Ladder Progressions

One career line begins with the quality assurance aide and continues to quality assurance technician. At this point the individual should be able to opt to continue in an educational program leading to [illegible]tion physicist or to continue with a program that prepares him or her to be a radiologic technologist. At the radiologic technologist level an individual could decide to go for training as an educator-supervisor or to be prepared to become a radiation physicist.

The interrelationship of the skills and knowledges needed for radiologic technology and quality assurance makes it possible to sequence the training in a radiologic technology program in such a way that a student would be prepared for employment as a quality assurance aide and a quality assurance technician while in the process of being trained

Figure 2. SUMMARY OF JOB STRUCTURE AND CAREER LADDER RECOMMENDATIONS




* Tasks in box with asterisk (*) not covered by data.
Note: For task content see Appendix E.

to be a radiologic technologist. Very little training would go to waste; employment would be available to students part way through the educational program; and students not qualified to complete the program would be able to offer marketable preparation for a job, at least at the aide or technician level. The attention to quality assurance in this sequencing would do the technologist no harm when he or she is ready to do patient examinations.

This approach would also leave to the radiation physicist program those aspects of physics, radiobiology, and electronics not required before the professional level is reached. (See Tables 2 and 7 in Volume 2.)

Sequenced this way, small institutions requiring that radiologic technologists perform quality assurance technician tasks could opt for the full complement of training, whereas large institutions could save on costs by hiring at the technician level, saving the radiologic technologist for examination functions.

The second career line begins with the patient care aide and continues to patient care technician. At this point the individual should be able to choose to continue in an educational nursing program leading to licensure and eventual clinical or emergency care specialties, or to continue with a program that prepares him or her to be a radiologic technologist. At the radiologic technologist level the options discussed above are all available.

The nursing skills and knowledge required for radiologic technology make the same type of sequencing possible in the patient care line

as was suggested for quality assurance. The only differences would be the specific content of the sequences. (Both types of sequences are presented in Volume 2.)

Cross-over lattice possibilities are the basis for the career ladder options into radiologic technology from the quality assurance and patient care ladders. The quality assurance technician and the patient care technician both have sufficiently transferable training that is relevant (although different in each case) for continuing towards radiologic technology as well as towards nursing or physicist occupations.

Figure 2 also presents a cross-over lattice possibility at level 1. A decision at the entry level to change one's direction from people-oriented to equipment- and materials-oriented work is not a waste of much training investment. Such options should be available early to allow individuals to find the orientation best suited to their needs, interests, and abilities.

Figure 2 also suggests an administrative task progression that can be combined with the career ladders presented. It can be used to produce supervisors and administrators in either major career line and to round out the jobs.

## PREPARATION FOR EDUCATIONAL LADDERS

The tasks assigned to any given level within a factor are likely to be representative of the central tasks of a job. Naturally, any job will also include certain peripheral tasks not on the factor

which reflect the administrative or institutional idiosyncrasies, paper work, conferences, etc., usually associated with any job. In some cases a real job may combine the tasks in more than one factor, such as when an institution is not large enough to differentiate jobs. However, for the purposes of job or educational ladder design, the tasks at a given level within a factor suggest the most rational assignment of major duties, since they represent the maximum application of a given educational investment.

Assuming the transferability and the additive nature of the HSMS skills and knowledges, HSMS task data can be used to identify the necessary curriculum content for each step in a ladder, and can be used to identify the educational gap between levels. For any given factor, the difference between the highest scale value for each skill and knowledge category required at a particular job level and the highest scale value for skills and knowledges required at the next level, plus any new skills and knowledge categories needed at the next level, defines the educational gap between levels. This is the rationale for the design of educational ladders. (See Table 2 in Volume 2.)

Having educational ladders to parallel career ladders is offerred as an alternative to the practice in many associate and baccalaureate degree programs where course content is presented without regard to any work-related sequence. For example, course content which is needed only for level 3 tasks may be presented early in the program, before material needed for level 1 and 2 tasks. Science and liberal arts courses may be taught early in the program. The effect is to

screen out students. As a result, the students who fail do not have enough occupational training to qualify in any health services job market. The students are penalized for failure which could be unrelated to actual work requirements for lower level jobs, or even for the job in question.

The job structure and career ladder recommendations presented earlier in this chapter can be given educational substance by use of curriculum objectives based on the HSMS method. We have designed curriculum guidelines for the radiologic technologist that can produce any of the sequences discussed above. The curriculum guidelines include curriculum outlines, behavioral curriculum objectives, and teaching and evaluation strategies.

Our curricula, whether one monolithic program or in sequences by level, combine six major occupational-educational units. At level 1 there are two units, one in patient care and one in quality assurance. At level 2 there are two units, one in patient care and one in quality assurance. At level 3 there are two units, one in radiologic technology and one in administration. The six occupational-educational units make possible three sequences of skill and knowledge curriculum objectives. One assumes that the radiologic technologist is an indivisible occupation. The second follows the aide, technician, and radiologic technologist sequence in quality assurance. The third follows the aide, technician, and radiologic technologist sequence in patient care. The work is presented in Volume 2.

# CHAPTER 3

## USING TASK DATA TO MAKE RATIONAL USE OF MANPOWER

This chapter is directed to the hospital or department administrator who is interested in implementing the job structure and career ladder recommendations in Chapter 2, or who wishes to use the task descriptions of Research Report No. 7 and the task data of this report for performance evaluation.

The chapter assumes that good intentions about providing upward mobility to workers and quality care to patients are no guaranty that they will be translated into practice. The institution must be convinced that there are practical reasons for doing so -- that it makes economic sense. Most people are already convinced of the social and moral desirability of providing upward mobility to health service workers and subscribe to the principle of promoting patient safety and quality care. They are not always convinced that such policies are economically viable.

Even though public and voluntary hospitals operate as nonprofit institutions, they are under increasing pressure to hold down costs. Upward mobility and quality care have to offer cost benefits. This chapter reflects such cost concerns. We think that there are practical benefits to be derived from using HSMS data and recommendations, and present this chapter as a guide to their use.

This first section, below, discusses the economic rationales for job structuring, restructuring, and the development of job ladders along the lines suggested in this report. The second section describes

how the administrator can use the data in this report and in Research Report No. 7 to rationally structure or restructure jobs. It shows how to examine the allocation of work in the institution in terms of task overlap and the assignment of tasks to levels, and describes the creation of new jobs. The third section discusses the development of a career ladder program, cost saving strategies, and trainee selection. The fourth section deals with the use of HSMS data to evaluate institutional performance. It provides a mini-manual for using HSMS task data to create performance evaluation instruments.

## RATIONALES FOR JOB RESTRUCTURING AND CAREER LADDERS

The HSMS method makes it possible to analyze tasks in terms of their skill and knowledge requirements and their relationship to other tasks and job levels. It therefore becomes possible to assign tasks to job titles to make optimum use of more highly trained and more expensive employees, and to make sure that the work is being carried out by staff who are properly trained to provide quality output.

The assignment of tasks to job titles is job structuring or restructuring. The arrangement of jobs into a promotional sequence from one level to another is job ladder construction. It is not always necessary to do job restructuring in order to design and implement job ladders; it is possible to derive advantages from job structuring or restructuring without having to arrange jobs into a promotional ladder. We discuss this below.

The costs to consider in structuring or restructuring jobs are salary and education costs. Direct education or tuition costs can

be borne by students, employers, or society; education costs, however, are also reflected in salary levels. The education time needed to prepare for jobs is highly correlated with salary levels. When we talk of high-level staff or jobs, we imply high salaries, skill, and knowledge requirements, and long, expensive periods of educational preparation. Conversely, low-level jobs are understood to mean low levels of educational preparation and low salary levels.

Job Structuring and Restructuring

Job structuring and restructuring can provide cost advantages if tasks are assigned to jobs so that the skill and knowledge levels required for tasks are compatible with the educational and salary levels of the jobs to which they are assigned. Allocation of low-level tasks to high-level jobs is wasteful of salary and education costs. If there are shortages of high-level personnel, the waste is felt as decreased services.

It also makes economic sense to assign tasks to jobs so that the skill and knowledge requirements for all the tasks in a job are similar. Assigning tasks requiring different, non-overlapping skill and knowledge requirements to a single job increases the amount of educational preparation needed to do the job, even if all its tasks are at the same level. This prolongs the educational preparation time needed and probably inflates salary levels.

Job structuring and restructuring may be done to make jobs at lower levels less boring for workers in order to improve morale and thereby improve performance and/or reduce turnover costs. Such "job enlargement" can be done economically by increasing the variety of task ac-

tivities in a job while still assigning tasks which require the same basic investment in skill and knowledge training.

Job structuring is needed when the institution is to provide a new service or function, or is to utilize a new technology. The relevant economic manpower questions are: What are the tasks involved? At what job levels should the tasks be assigned? To what existing job titles might they be assigned to minimize new educational preparation and to disrupt current work the least? Is there justification in creating one or more new jobs? Is the development of a job ladder appropriate? We discuss these questions later in this chapter.

Job Ladders

Job or career ladders provide upward mobility for the in-house labor force of an institution. Promotional lines provide for a supply of new entrants into jobs as older incumbents retire, are dismissed, or as more staff are needed to fill a job title.

The most powerful economic reason to have a career mobility program is to fill chronic vacancies at middle and upper job levels. In a field such as health services, most promotional lines would require additional education as an individual goes from one level to another. An economically desirable career mobility program would provide job ladder sequences that minimize the additional education needed between levels. If a job ladder starts from an entry level job with few vacancies, and progresses from one job level to another within interrelated task groupings to the level where shortages exist, the amount of educational investment required between each level would be minimized, and staff need

be trained only for the educational gap between one level and the next.

There are other economic arguments in favor of job ladders. By selecting in-house staff in appropriate current jobs to move up in a job ladder, the institution can cut the costs that are incurred in orienting new employees. A program of upward mobility can also become an incentive for efficient performance if selection for upgrading is partly dependent on the quality of current-level job performance. Since trainees currently successful at one job level are likely to be successful at the next level (because of similar job content), the failure rate may be reduced. A career ladder program may also reduce the costs of turnover to the degree that high turnover reflects discouragement with "dead-end" jobs.

Actual salary costs may be lower with the use of upgrading programs than if staff are hired from the outside. The staff selected for upgrading will be at the top of their salary range when selected. They will be replaced in their former jobs by staff who are themselves newly upgraded and who will be entering at the bottom of the salary range; the trainees will all enter at the bottom of the salary range for their new jobs. Competition among institutions to attract outside individuals whose training is in short supply creates an inflationary pressure on salary levels. An in-house career mobility program adds to the supply of scarce labor and reduces inflationary pressures. We discuss strategies for job ladder construction later in this chapter.

When shortage jobs are at a high level, with no related jobs at intermediary levels, job structuring or restructuring may be needed to provide job ladders. If the educational distance from an entry job to a short-

age job is a matter of several years, one cannot talk about a viable job ladder. For example, a one-step rise from the darkroom aide to the radiation physicist would be unrealistic. But a ladder from the aide to the technician level, and from there to the technologist level can ultimately lead to the professional physicist level in reasonable stages. [1]

The creation of a new job at an intermediary level on a ladder or to provide a new service or function is a form of specialization of labor that may be cost saving within limits. As different components of work are separated and assigned to different jobs, the work can be done more efficiently and more economically. Lower level tasks can be grouped into jobs at lower salaries. The limit to this approach is that the institution must be large enough to provide full-time work in each of the subdivided specialties. Short of this, workers would not be efficiently utilized. We discuss this question later in this chapter.

## USING HSMS TASK DATA TO STRUCTURE JOBS

Assuming that the administrator of a department of diagnostic radiology is interested in the rational structuring of jobs in the department, HSMS data can provide the raw materials. We have done the task identification and descriptions, have identified the major groupings of tasks and the levels of tasks, and have made some job structure and career ladder suggestions. The data are provided in Research Report No. 7 and in this report. Now the administrator can adapt the data, analyses, and rec-

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[1] It is important to note that a job ladder progression refers to the relationship among job titles. A given individual may not move up on all the rungs of a ladder. At any point in time incumbents at one level in a ladder are the population from which those who will go to the next level on the ladder are selected.

ommendations for use in his or her own department.

## Analysis of Job Structures

### Data Preparation

The first step is for the administrator to decide on the job titles to be examined; the second step is to identify the tasks being carried out in those titles; the third step is to analyze the pattern of distribution of the tasks in terms of task overlaps across jobs, the levels of tasks in jobs, and the groupings of tasks in jobs.

The administrator starts by selecting the job titles to be examined. These are placed on a reference list. The list should include all the in-house titles of interest along with the salary or salary range for each. Next, a HSMS job level should be assigned to each job on the list. Table 1 and the explanatory text in Chapter 1 present the job levels. In Table 1, the left-hand column indicates the HSMS levels, and the right-hand column gives an idea of the titles one can find at these levels. A way to check the appropriateness of the job level designations is to note whether the rank order of the job titles by salary level is the same as the rank order of job titles by the HSMS job level designation.

The next step is to determine which individual(s) are familiar with all the work being done by all the incumbents in the job titles on the list. This may be the administrator, or different supervisors may be familiar with different titles. These individuals will become resource persons who will be asked to provide the basic information on the current allocation of tasks to titles. We can call them "respondents."

The next major step in the analysis is to determine which of the 368 tasks covered by HSMS in diagnostic radiology are being carried out in job titles in the department or in titles related to the department. It may be best to get an overall sense of where the activities are being done before getting detailed information for each title.

The HSMS task inventory reference for the 368 tasks is Volume 4 of Research Report No. 7, which presents the extended task names.[2] These provide good content references, so there should be little confusion about what work activities are being referred to. (Appendix A, which presents the abbreviated task names, is less detailed and is used later, after the basic identifications are done.)

The HSMS tasks are screened so that a final list includes only tasks being done at the institution. The next step is to find out in which job title or titles each task is done. For each in-house job the entire list is considered to ensure that all the tasks for a given title are covered. This means that a copy of the entire task inventory of all the tasks is prepared for each interview with each respondent.

The respondent is asked to indicate which tasks in the inventory are carried out by incumbents in a given title. At this point it may be decided that it is important to know which tasks are carried out by individual employees in a title. Separate lists would then be prepared for each, and each would have the appropriate job level designation by title. When the tasks assigned to an individual are noted, an effort should be made to

[2] Op. cit.; also, see Preface.

include out-of-title work, because this may be of major economic interest. This is an in-house analysis, and no security would be endangered.

Now we presumably have a task list for each title and individual being studied. Each contains all the tasks done in that job. (The code number and abbreviated task names in Appendix A are useful at this point.) Next to the name of each task two additional pieces of information are needed. The first is the HSMS job level designation; the second is the HSMS factor name and/or number. (The factor information is available from Appendix D, Table D.2. The job level designations of the tasks are presented by factor in Appendix E.)

A third piece of information may be of interest to the administrator. That is the frequency with which the task is carried out in a given job. This information will be helpful if there is interest in the relative importance of a task in the structure of a job. The basic information is obtainable from the respondents. In order to make it possible to compare task frequencies across jobs, HSMS developed a scale for frequency. It is the first scale presented in Appendix C, and can be used to scale tasks for how often they are carried out in the course of a day or a year.

If there is interest in an <u>overall assessment of the manpower utilization pattern in the department</u>, the next step is to create an array that contains the information of interest. We begin by arranging the <u>job titles</u> (and the names of individuals within titles) in <u>columns</u>, from left to right, in descending order by HSMS job level and/or salary level. Within job levels the titles should be arranged by HSMS factor. The factor for

a job is determined by the most prominent factor showing on the task list collected for the title (or individual). The rows in the array are to be all the tasks found in the department, arranged from top to bottom in descending order by HSMS job level, and within job levels by the same factor order used for the columns.[3] The entries in the array are x's. Working with each task list separately, one fills in a column at a time, placing an "x" in the appropriate column if a given task is found on the given job's list. Figure 3 is a hypothetical example of such an array. (We used Appendix E for the task numbers, levels, factors, and titles; we assume twelve incumbents, listed by number.)

The array provides an overall view of the extent and location of task overlap and the appropriateness of current allocations of tasks to job titles by levels and factors. One examines the overlap of tasks across job titles or incumbents by reading across the array; one examines the mix of tasks in jobs by level and factor by reading down the columns. An ideal utilization pattern would be roughly in the shape of a diagonal, falling from left to right (as wide as the adjacent columns in a given factor; as high as the adjacent rows in a given factor within a level). Figure 3 shows this pattern with the exception of Tasks 490, 74, and 275.

## Task Overlap

Task overlap occurs when a task is carried out in more than one job title (or across more than one incumbent of a title if there are different jobs within a title). Not all overlap is undesirable or avoidable. There are always overlap tasks to be done that provide the mortar

[3] Appendix E can be used to order the tasks. To save space, code numbers can be used to designate columns and rows, since the entries will be x's.

Figure 3. HYPOTHETICAL ARRAY OF TASK ALLOCATIONS BY JOB TITLE

| Job Levels[a]: | | | 8 | | 5 | 4 | | 3 | | 2 | | 1 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Factors[b]: | | | I | II | VI | III | IV | III | A | IV | VI | IV | VI | |
| Job Titles[c]: | | | Non-neur. Rad. | Neuro. Rad. | Physicist | Rad. Tech. Supr. | Pt. Care Supr. | Rad. Tech. | Admin. Tech. | Pt. Care Tech. | Qual. Ass. Aide | Pt. Care Aide | Qual. Ass. Aide | |
| Incumbents: | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Level | Factor | Task Code | | | | | | | | | | | | |
| 8 | I | 441 | X | | | | | | | | | | | |
| | | 329 | X | | | | | | | | | | | |
| | | 448 | X | | | | | | | | | | | |
| | II | 404 | | X | | | | | | | | | | |
| | | 397 | | X | | | | | | | | | | |
| | | 430 | | X | | | | | | | | | | |
| 5 | VI | 528 | | | X | | | | | | | | | |
| | | 546 | | | X | | | | | | | | | |
| | | 542 | | | X | | | | | | | | | |
| 4 | III | 82 | | | | X | | | | | | | | |
| | | 7 | | | | X | | | | | | | | |
| | IV | 158 | | | | | X | | | | | | | |
| | | 305 | | | | | X | | | | | | | |
| 3 | III | 526 | | | | | | X | | | | | | |
| | | 362 | | | | | | X | | | | | | |
| | | 363 | | | | | | X | | | | | | |
| | A | 496 | | | | | | X | | | | | | |
| | | 131 | | | | | | | X | | | | | |
| | | 272 | | | | | | | X | | | | | |
| 2 | IV | 299 | | | | | | | | X | | | | |
| | | 33 | | | | | | | | X | | | | |
| | | 143 | | | | | | | | X | | | | |
| | | 308 | | | | | | | | X | | | | |
| | | 243 | | | | | | | | X | | | | |
| | VI | 535 | | | | | | | | | X | | | |
| | | 548 | | | | | | | | | X | | | |
| | | 549 | | | | | | | | | X | | | |
| 1 | IV | 290 | | | | | | | | | | X | | |
| | | 190 | | | | | | | | | | X | | |
| | | 193 | | | | | | | | | | X | | |
| | | 490 | X | | | | | | | | | X | | |
| | | 74 | X | | | | | | | | | X | | |
| | VI | 147 | | | | | | | | | | | X | |
| | | 275 | | | | | | X | | | | | X | |
| | | 69 | | | | | | | | | | | | X |
| | | 552 | | | | | | | | | | | | X |
| | | 79 | | | | | | | | | | | X | |

[a] Level 8: specialized advanced professional; level 5: professional; level 4: educator, supervisor; level 3: technologist; level 2: technician; level 1: aide.

[b] Factor I: Non-neurologic Radiology; Factor II: Neuroradiology; Factor III: Radiologic Technology; Factor IV: Patient Care; Factor VI: Quality Assurance; Non-factor A: Administration.

[c] Fill in the in-house titles.

to hold the central tasks in a job together. There can be duplications that reflect the different locations or shifts in which the work is carried out. However, when there is duplication of the central work in a given department, this bears close examination; thus, the overlap data in the array should be given a careful analysis.

The most important type of overlap to look for is where the same task is found in jobs that are at different levels. The allocation of low-level tasks to high-level titles is wasteful. The allocation of high-level tasks to low-level titles implies inadequate performance or wasteful training. Given acceptable performance of a task in the titles where it is currently overlapped, there is a prima facie economic argument for downward assignment of an overlap task to the lowest level in which it is currently found. In Figure 3 there are three such tasks.

Sometimes the overlap reflects the case where supervisors fill in for absent staff. This may be a waste of expensive supervisory time. One solution might be to develop a "flying squad" for lower-level jobs. Such staff would be trained for several jobs at the aide level and would be on call to fill in for absentees. One flying squad could cover patient care and another quality assurance, or the squad could cover both factors. The squad(s) would serve the purpose of providing a source of experienced manpower to cover staff absences at the aide level. By virtue of this experience, employees at the aide level could later make informed choices about the specialty in which they would like to rise. Management would be in a position to take account of especially gifted employees and encourage them. Finally, the rotation would permit job enrichment and add variety.

Sometimes overlap of tasks across job levels reflects the refusal of professional staff to delegate work. We have found that some professionals prefer to carry out lower-level tasks when they are not comfortable about the quality of the performance on the part of lower-level staff. Discovery of this kind of overlap actually pinpoints job performance and training inadequacies. The solution is to provide the remedial training needed so that higher-level staff can rely on the quality of work assigned to lower-level staff.

The in-house analysis of the overlap data should result in the separation of necessary from unnecessary task overlaps, a design for the rational restructuring of jobs, and any other steps needed to remedy the problems uncovered.

## Job Structure By Task Level and Factor

The economic significance of examining the allocation of tasks to jobs by level has already been discussed. The data in the array and on the separate lists provide the basic information. It is now possible to discuss the percentage of tasks at various levels for a given job. Again, the economic goal is the allocation of tasks at a given level to jobs at that level. As was indicated above, most jobs cannot be held together without one or two tasks that are essentially simple and/or administrative. The point is to use the percentage distributions and task frequency data to examine whether current allocations are sound.

The allocation of lower-level tasks to higher-level jobs suggests waste. It is also important to consider the presence of higher-level tasks in lower-level jobs. In a case where a task is rated by HSMS at a

level higher than the job in which it is found, the task may be beyond the reach of the incumbent's experience and training, and performance may be unsatisfactory. Alternatively, the staff in this job may be receiving training for the one task at levels that are beyond the needs for all the other tasks of the job, and this would be wasteful of training. (A third explanation could be that HSMS is incorrect in its evaluation of the task's level.)

The analysis of the composition of jobs by task factor is similar to the analysis of the task levels. The array and the lists provide insights about the breadth of training required for the jobs. A job made up of tasks that cross several factors may require training in a larger number of subject areas than is economically warranted. For example, if the same staff member were administering medication and testing x-ray equipment, an investment in training in pharmacology subjects and in technological subjects would be required. With no transferability from one to the other, and no likelihood that this combination would be found in other lateral or higher jobs, we have a wasteful job structure.

Creation of New Jobs

A new job may need to be created as a result of the analysis of task allocations described above, or to provide an intermediary job between high and low level jobs, or to provide for a new function, or to utilize a newly available technology. The key to structuring a new job is to know all the tasks to be covered, their job levels, and their factor designations. Frequency data reflecting the expected work loads to be assigned would also be helpful.

The decision to institute a quality assurance program in diagnostic radiology provides an example of the type of analysis that might be considered in the creation of new jobs, given the principles already described.

At present, quality assurance tasks are not found in every hospital, and certainly not all the tasks we present are found in any one institution. When the tasks we identified are found currently they are variously located in physicist, radiologic technology supervisor, and/or radiologic technologist titles.

Assuming that the trend is to adopt such tasks and to institute quality assurance programs, what is the best job structure to contain the technician-level tasks? We have suggested the cost-saving nature of specialization of labor, the creation of a quality assurance technician job, and the allocation of level 5 tasks to a radiation physicist job. This makes sense if the institution is sufficiently large to benefit from the newly created quality assurance technician job.

However, if a hospital has only a few x-ray machines, there is no point in hiring someone to do nothing but test them periodically. When this is the case, the HSMS designation of level and factor for the tasks can be used to decide how the technician-level tasks should be allocated among existing jobs. The best decision will vary for different institutions. The decision should be the result of an analysis of task frequency data for current tasks and for the quality assurance tasks. The reasoning might proceed along the following lines.

Should the technician tasks be taught to the aide and added to the aide's current duties? The new costs would be for training and a salary increase, because now the aide job would include technician-level tasks. Is it better to teach the tasks to the technologist and add them to the technologist's current duties? The new costs would be those for training and the hidden costs of making less than optimum use of the technologist's time in technician-level tasks. With the use of data on frequency and current work loads and flows, a sound economic decision can be reached.

What is inescapably apparent is that there is little justification for assigning the technician tasks to a physicist, who is an expensive employee. If the reason for a job structure in which the physicist is doing the technician tasks is that there isn't full-time work for the physicist anyway, two answers come to mind. One is that the true function of the physicist may not be understood, and appropriate tasks may be missing. The other is that it may be sensible for a small institution not to employ a full-time physicist, but to retain a consultant who will set up and run the quality assurance program as needed.

Job Descriptions

It may be of interest that the material discussed in this section lends itself to the development of job descriptions. They can be as simple as a listing of the abbreviated task names, or as complicated as the detailed task descriptions in Research Report No. 7. We believe that the extended task names provide a good balance of brevity and detail. When edited to reflect the work done at the given institution, they provide objective, unambiguous references. They are useful for wage and salary negotiations and for personnel counseling.

## CAREER LADDERS AND COST SAVING STRATEGIES

Let us assume that an institution has decided to develop a program for upgrading staff in job ladder progressions. It might be convinced that this approach is most efficient in the long run; it may have decided that this is the way to expand the services it provides, whether in sheer quantity when demand increases, or in the provision of new services or functions; it may have decided that this is the way to fill chronic vacancies. It may be that the commitment to upward mobility has been brought about through collective bargaining, and a portion of the wage package will be set aside for the upgrading-training of staff. In any of these circumstances there are basic decisions to be made that can affect costs and the success or failure of the program. This section brings together various insights gained by HSMS about the cost aspects of career mobility programs. We hope that they prove useful.

### Overview

Unlike the situation where students gain their occupational preparation before they enter the labor force, an upward mobility program is concerned with students who are employed adults and who very likely are the main source of support of themselves and their families. We are also dealing with hospital employers who need to provide their staff with occupational preparation while at the same time maintaining the quantity and quality of their productive output.

We are dealing with jobs, most of which require instruction in formal disciplines. The subject matter must be imparted by teachers and learned in the classroom and in supervised clinical practice. Unlike many

factory or civil service staff, the health worker cannot "pick up" what is needed in the higher-level job by simply observing other workers during the course of a work day in his current job. We are also dealing with jobs the entry to which is circumscribed by requirements such as licensure, certification, graduation from AMA-approved or otherwise accredited programs, and/or academic degrees. In most cases licensure and certification require graduation from accredited programs as well as passing examinations.

An in-house upward mobility program involves four basic types of costs and alternative ways of dealing with them. There are education costs, released-time costs, relief worker costs, and trainee failure costs.

Education costs cover classroom instruction and clinical practice. These would be faced by anyone entering study for an occupation. The options and choices about which we have something to say are as follows:

1. There can be an in-house (hospital-based) program in which the institution runs the program; or there can be an academic program in which a student accumulates academic credits towards a degree at the associate, baccalaureate or masters level.

2. The program can be designed as an educational ladder with course work sequenced so that the whole program leads to the top of the ladder and shorter segments lead to lower-level jobs, so that students can exit and reenter the program at job-related intervals; or there can be discrete programs designed for each job.

3. Time schedules for instruction can be geared to full-time students and regular academic semesters; or they can be geared to the time requirements of employed students.

Released-time costs are payments to trainees while they are studying to permit them to maintain incomes. The options include finding outside assistance to pay employees, counting these costs as fringe

benefits along with health insurance and passing them along as production costs to third-party payers, and/or having employees and/or educational institutions share in the costs.

Relief worker costs cover the salary for employees who will provide the relief work while trainees are studying. Among the options are hiring temporary employees to provide the relief work for individual trainees or using a staged approach in which the workers who will replace the trainees in their former jobs when the latter are upgraded are the ones to provide the relief work. We discuss a strategy for this below.

Trainee failure costs are incurred when trainees fail in their upgrading-training programs and are not able to fill the upper-level jobs. The selection criteria for trainees can affect success or failure. There is an important set of alternatives about which HSMS has something to say below.

Education Costs

We have already discussed why sequential educational programs based on job ladders save education costs by eliminating redundant education and providing reinforcement and transferability of training. We now suggest that it is more economical in the short and long run for hospitals to give up the production of educational programs at technician and technologist levels. We suggest that they combine into consortia on a city-wide or system-wide basis to purchase educational programs from academic institutions which can offer accredited programs and academic credits usable toward college degrees.

The educational institutions could be persuaded to offer programs that are properly timed and sequenced to service the career ladder programs adopted by hospitals if there are large numbers of students involved. The movement to work/study, continuing education, and work-oriented timing for course hours has been growing in colleges and universities since the late 1960's. Consortia can be created of hospitals in a system such as a municipal or voluntary system, or in a geographic area. Their function would be to adopt mutually acceptable job ladders and to purchase educational programs for a consortium's pool of trainees.

The alternative is having health care delivery institutions provide internal training for their manpower needs. The training produced is often so specific to the needs of the institution that the trainee finds it of little use for upward mobility or even for lateral movement in the job market. This is particularly true in the so-called "new career" titles. Since the institutions themselves are not permitted to provide academic credits, the training is of no help in the attainment of the degrees which are a part of the credential system and are needed for higher-level jobs.

Given the current time requirements for accredited programs (two years for radiologic technologist) there is a good argument for using the required time to accumulate degree credits as well as occupational certification for students.[4]

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[4] It is worth considering that there is a two-year requirement for the radiologic technologist program regardless of whether it is a hospital-based program or offered in a community college and leading to an associate degree. May one conclude that the associate degree program covers the AMA "Essentials" in less than the equivalent of two years and handles the liberal arts courses in the remaining time? If this is true, is there a waste of student time in hospital-based programs?

Aide-level training could include remediation and be used to ready workers to advance later. It might be best to provide this in conjunction with programs leading to high school equivalency diplomas or college-level credits. Everyone at the aide level should have the chance to receive high school equivalency training, especially credits in the high school subjects required for entry to associate or baccalaureate-degree programs. Aides should be able to receive credit for their work experience where this is appropriate.

Given the number of trainees for upgrading programs that hospital systems or consortia can offer, educational institutions could reduce per capita costs through the use of plant and faculties in courses offered in the evening, on weekends, during vacations, and at other non-peak times. The member hospitals would be natural affiliates for the clinical training.

A system-wide consortium approach could combine hospitals, educational institutions, and the local health services trade unions and professional associations to make maximum use of federal, state, local, and foundation funding for its programs. It is a full-time job to locate the funds, write the proposals, and put the packages together. But this can be done efficiently on a large, city-wide or system-wide basis.

Released-Time and Relief Costs

It is desirable to retain students in their jobs and provide them with released-time training. The hospital retains the services of current staff; the employee maintains an income source; and the educa-

tional institution may be able to use its plant at maximum efficiency. Released-time training could be passed on as a cost of service, but, in addition, employees may wish to accelerate their training and contribute by studying without compensation on weekends, holidays, and during vacation time.

In our strategy to minimize released-time and relief costs, we start with the assumption that a career ladder, such as that leading to radiation physicist or leading to radiologic technologist, will be a part of an overall manpower planning program undertaken by the institution. In that context it is important that the upper-level "target" job on a ladder be one that will have openings for newly trained staff to fill. These openings could come about due to new or expanding hospital services, turnover, retirement, or chronic current vacancies. The number of vacancies to be filled must be known before planning can take place. It is also critical that money be in the budget for the job titles to be filled when the training ends and the trainees are ready to work in the titles.

It is also important that entry-level jobs on a ladder be able to be filled easily; that is, that individuals are available to be recruited and trained to fill the entry-level jobs -- that there are no labor shortages at the gate.

If the entry-level job is one in which employment may be reduced in the future, then the upgrading program solves the redundancy problem for staff that would otherwise be let go. No new staff are needed at entry levels, and the cost of upgrading is reduced by the amount that would normally be needed to recruit, train, and employ new replacements.

We suggest a multi-staged, coordinated system of training to fill vacancies and provide replacements. It involves half-time study and full-time income. It includes double-track staging to provide training at minimum cost with no loss in production. For the trainees, it provides the maintenance of income and the job security they require while guaranteeing maximum upward mobility.

Double-track staging means that two educational programs run simultaneously. Each program is for half the trainees and runs during the hours that the other half are working. The trainees work during non-overlapping time periods; study can overlap for weekends, holidays, and vacations.

The strategy for double-track programs is based on the following considerations. If trainees work half time and train half time, and if relief workers are to be used to maintain output, one relief worker can relieve two trainees, but only if the two trainees are in <u>different</u> time slots. Anything else is a waste of relief worker costs. We prefer alternate months, weeks, or days for the tracks rather than alternate half days, because half days are wasteful of travel time and the warm-up time needed to refocus trainees' attention from study to work and back again.

The multi-stage strategy dovetails all the steps in a career ladder. With this approach released-time and relief costs can be kept below the cost of staffing the jobs whose vacancies are to be filled. Figure 4 provides a hypothetical example. It shows how dovetailing of programs, maximum use of relief workers, and non-overlapping the work/study time of employees in upgrading-training can keep the costs to a minimum.

Figure 4. A MINIMUM COST STRATEGY FOR UPGRADING: STAGED SEQUENCES



| Stage of Program and Jobs by Level | Va-cancies | Employment by Function: Doing Normal Work | Relief Trainees[a] | Training for Entry Level Job | Upgrading Training[b] | Full-time Work Equivalent | Employment by Salary: Top of Range | Bottom of Range | Total | Average Monthly Wage Bill |
|---|---|---|---|---|---|---|---|---|---|---|
| 0. Before program: | | | | | | | | | | |
| Technologists(3) @ $1,000-$1,600mo. | 8 | 12 | | | | 12 | 12 | | 12 | $19,200 |
| Technicians(2) @ $ 830-$ 900mo. | | 12 | | | | 12 | 12 | | 12 | 10,800 |
| Aides(1) @ $ 660-$ 750mo. | | 12 | | | | 12 | 12 | | 12 | 9,000 |
| (Budgeted vacancies at top of range) | 8 | | | | | | | | | (12,800) |
| Total | | 36 | 0 | 0 | 0 | 36 | 36 | 0 | 36 | $39,000 |
| (Total including vacancies) | | | | | | | (44) | | (44) | (51,000) |
| 1. Hire and prepare 2 for aide jobs: (to free 2 aides to relieve 4 aides who will go into training to be technicians in Stage 2). New hires = 1/4 technologist vacancies to be filled. Time required: training for level 1. | | | | | | | | | | |
| Technologists | 8 | 12 | | | | 12 | 12 | | 12 | $19,200 |
| Technicians | | 12 | | | | 12 | 12 | | 12 | 10,800 |
| Aides | | 12 | | 2 | | 12 | 12 | 2 | 14 | 10,320 |
| Total | 8 | 36 | 0 | 2 | 36 | 36 | 36 | 2 | 38 | $40,320 |
| 2. Upgrading training of aides begins: | | | | | | | | | | |
| a. Two aides relieve 4 aides selected for training to be technicians. Two-track program alternates work/study. Time required: training gap between levels 1 and 2. | | | | | | | | | | |
| b. Halfway through period another 2 are hired, trained to be aides. (Time required overlaps with a.) | | | | | | | | | | |
| Technologists | 8 | 12 | | | | 12 | 12 | | 12 | $19,200 |
| Technicians | | 12 | | | | 12 | 12 | | 12 | 10,800 |
| Aides | | 8 | 2 | 2[c] | 4 | 12 | 12 | 4 | 16 | 10,980 |
| Total | 8 | 32 | 2 | 2[c] | 4 | 36 | 36 | 4 | 40 | $40,980 |

[a] Assumes that each relief worker relieves 2 employees who are each in half-time upgrading training.
[b] Assumes that upgrading trainees work half time and study half time at full-time salaries.
[c] For half the period.

Figure 4. A MINIMUM COST STRATEGY FOR UPGRADING: STAGED SEQUENCES (continued)

| Stage of Program and Jobs by Level | Vacancies | Employment by Function: Doing Normal Work | Relief Trainees[a] | Training for Entry Level Job | Upgrading Training[b] | Full-time Work Equivalent | Employment by Salary: Top of Range | Bottom of Range | Total | Average Monthly Wage Bill |
|---|---|---|---|---|---|---|---|---|---|---|
| 3. Upgrading-training of technicians begins: | | | | | | | | | | |
| a. Four aides newly trained as technicians are upgraded. | | | | | | | | | | |
| b. Four technicians relieve 8 technicians selected for training to be technologists. Time required: training gap between levels 2 and 3. | | | | | | | | | | |
| c. Two new hires are trained to be aides one quarter way into the period (the time required overlaps). | | | | | | | | | | |
| d. Halfway through the period 2 aides relieve 4 aides selected for training to be technicians (the time required overlaps). | | | | | | | | | | |
| e. Three quarters of the way into the period another two are hired and trained as aides (unless fewer aides will now be needed than at start). (The time required overlaps so that total time is as in a.) | | | | | | | | | | |
| Technologists | 8 | 12 | | | | 12 | 12 | | 12 | $19,200 |
| Technicians | | 4 | 4 | | 8 | 12 | 12 | 4 | 16 | 14,120 |
| Aides | | 8 | 2 | 2[d] + 2[d] | 4 | 12 | 8 | 8 | 16 | 9,960 |
| Total | 8 | 24 | 6 | 4 | 12 | 36 | 32 | 12 | 44 | $43,280 |
| 4. Full cycle completed: Eight vacancies filled; 16 staff upgraded; 8 new hires. | | | | | | | | | | |
| Technologists | | 20 | | | | 20 | 12 | 8 | 20 | $27,200 |
| Technicians | | 12 | | | | 12 | 4 | 8 | 12 | 10,240 |
| Aides | | 12 | | | | 12 | 4 | 8 | 12 | 8,280 |
| Total | 0 | 44 | | | | 44 | 20 | 24 | 44 | $45,720 |

[d] For a quarter of the period.

In this example the plan is to fill 8 technologist jobs (at an institution that is part of a consortium) in the length of time needed to train new aides, to train aides to become technicians, and to train technicians to become technologists in a half-time, work/study program. The ladder in quality assurance leading to radiologic technologist could be the example.

We assume that trainees study half time and receive full-time salaries. Current incumbents, including trainees for upgrading, are at maximum salaries for their lines and receive current wages until upgraded. New incumbents start at minumum rates.

Costs are reduced during the program by employing new staff only as needed in the staged sequences. All staff used for relief work are fully utilized and are retained at the end of the program to fill the slots vacated by the staff who have been upgraded.

We show that, if the 8 technologists were hired from the outside, the total salary cost of staffing 44 employees for one month would be $51,000 (or $47,000, depending on whether new technologists would be recruited at the top or bottom of their salary range). We show that at the end of the training cycle the same staffing of 44 employees would only cost $45,720 per month because the upgrading program reduces costs on every line where upgrading takes place. The additional cost savings from reducing training time by using an educational ladder to parallel the job ladder and from the elimination of orientation costs are not included.

Stage 0 in Figure 4 shows current staffing and costs on a monthly basis. (The salary figures are illustrative.)

In Stage 1 we hire two individuals (one quarter of the number of technologist vacancies) and train them as aides. All staff needed for relief work at higher levels are provided from in-house staff. Output is kept constant. (See the column for full-time equivalent employment.)

In Stage 2 the first training step takes place. The new aides are able to provide released-time relief for four aides who now study to become technicians. Halfway through the period another two aides are hired and trained, so that a total of four aides can replace the four who become technicians at the end of the training in this period.

In Stage 3 the second training step takes place. The upgrading of four aides to be technicians makes it possible to relieve eight technicians to be trained to become technologists. At a point one quarter way into the period, Stage 1 is repeated, and then Stage 2, so that two new aides again relieve four aides for study. With an additional two hired and trained, four new aides are available to replace the four aides who are upgraded to be technicians at the end of the period. The training is dovetailed so that a total of eight new technicians are available through upgrading to replace the eight technicians who become technologists at the end of Stage 3.

At Stage 4 eight vacancies have been filled, sixteen workers have been upgraded, and eight new employees have been hired. Sixteen jobs formerly filled by staff at the top of their salary range are now filled by staff at the bottom of their range. At no time do the costs meet or exceed what costs would have been if the vacancies were filled from outside.

Trainee Failure Costs and Selection Criteria

Given the need to minimize the costs and time involved in training, there is some incentive for the institution to train those individuals who are most likely to succeed in the "target job" (the job for which the trainees are to be prepared). If, in addition, the existence of an upward mobility program can improve the quality of performance of individuals in current jobs, the net cost of upgrading programs can be substantially reduced. The HSMS approach provides two selection criteria that can be assumed to predict trainee success because they tie functioning in the current job to functioning in the related target job. If we assume that the job ladder reflects an association of tasks that require related skills and knowledges, we may assume that the important tasks in jobs at varying levels on a job ladder are related. The HSMS criteria for trainee selection are as follows:

1. The current job title from which the trainees should be selected for a given target job is that just below the target job on a job ladder.
2. The incumbents within the job title from which trainees are to be selected should be those with the best ratings for current performance.

If employees believe that the quality of their performance in the current job will be a factor in trainee selection, their current performance will be improved; at the same time, the most able trainees can be selected. The attractiveness of these criteria is that the first one is impersonal; it focuses on all the incumbents in a given job title; the second criterion is reasonable, since it rewards good performance. It also reduces any testing to performance testing or rating of a small population. If performance evaluation is ongoing, no additional testing is required.

Another important criterion is that of motivation. It is a concept which can best be handled indirectly, since it is subjective. For the purpose of trainee selection, self-selection for training is an acceptable indication of motivation, provided that all employees have had adequate access to information about the availability of the career mobility training program.

In any system of upgrading, especially if trade unions are involved, the criterion of seniority must also be considered. Seniority is a perfectly acceptable means of choosing between two otherwise equal candidates, and its use as one among several criteria is compatible with the HSMS approach.[5]

## A Trainee Selection Strategy

Once the job title of the trainee population has been selected, the program can be announced. The potential trainee population would be those in the title who apply for the program, and this limited number of staff would be the ones whose current performances are evaluated as a basis for selection.

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[5] A different sort of criterion is expressed in the practice called "creaming," which involves taking the most educated applicants regardless of their current job. "Creaming" is successful in the short run largely because educational levels are roughly related to job ladder sequences, and education provides intellectual skills. However, after creaming is over and the better educated are chosen, there is then no model for continued selection. Another criterion used to select trainees is scores on aptitude tests. The use of aptitude tests is no better than the validity of the test used (that is, the extent to which the test reflects job content and is free of cultural or educational bias). The HSMS approach bypasses the inadequacies of aptitude tests by going directly to work-related criteria.

If a program of performance evaluation such as the one presented in the next section were underway, the available data might be sufficient to select trainees. Otherwise, assuming we are dealing with diagnostic radiology, performance evaluation would proceed as follows:

1. The tasks in the trainee population's job title would be identified as described earlier in this chapter. These would be designated by job level and factor, as presented in the appropriate table in Appendix E.

2. Experts, such as supervisors, would select the most central tasks in the trainee population's job. These would be the reference tasks for the evaluation.

3. Supervisors intimate with the applicants' work performance would be selected as raters.

4. A performance rating instrument would be prepared:

   a. The extended task name for each task selected would be presented (the extended task name as given in Volume 4 of Research Report No. 7).

   b. For each task, the name of the employee to be rated and the rater would be entered.

   c. For each task, the rater would be instructed to consider the task and the criteria for evaluating the outputs of the task or performance of the task.

   d. For each task, the rater would be asked to compare the given employee's achievement of output or performance criteria with others regularly performing the task.

   e. The same scale would be used for each task and for each employee to be rated. The instructions and scale would read roughly as follows:

      Please compare this employee's performance of the task listed above with the performance of other persons regularly performing this task. Consider the criteria for the output of the task or for performance of the task, and consider to what degree the criteria are met by this employee and by others in the same job title. Please check the statement that best describes your comparison of this person with the others performing this task.

9...( )...Distinctly superior with respect to others in title.

8...( )...Considerably above average with respect to others in title.

7...( )...Moderately above average with respect to others in title.

6...( )...Slightly above average with respect to others in title.

5...( )...Average with respect to others in title.

4...( )...Slightly below average with respect to others in title.

3...( )...Moderately below average with respect to others in title.

2...( )...Considerable below average with respect to others in title.

1...( )...Distinctly inferior with respect to others in title.

5. The scores of each employee being rated would be calculated. If an employee is rated by more than one rater, scores would be averaged.

6. The seniority of applicants would be used to select from among applicants with otherwise equal scores.

## Implementation

An institution committed to upward mobility as a continuous part of its manpower function must be aware that this requires planning and elaboration of the means for implementation. Such a program needs careful prior planning and work if it is to be designed to suit the needs of the institution and the needs of individual staff members.

We have found that the implementation of a career mobility approach necessitates changes within the institution such as the coordination of recruitment, training plans, and upgrading programs with the operations of the institution. Planning and a redirection of focus may be needed. No amount of commitment at high management levels can substitute for the involvement of middle and lower line personnel in the implementation of institutional change. The greatest enemy of a viable mobility program is staff ignorance of what is happening.

For this reason we believe that the issues of upward mobility should be discussed at every level in an organization and in cooperation with employee organizations where they exist. It should be noted that persons are less resistant to upward mobility for others when they have avenues open to themselves as well. Thus, a career ladder or lattices linking entry-level jobs through graduated sequences to the very highest professional and administrative jobs is most desirable if maximum support is to be enlisted.

## EVALUATION OF INSTITUTIONAL PERFORMANCE

Evaluation is much in the minds of health services delivery administrators. There is pressure to review work as a means to greater efficiency; more importantly, there is pressure to review work as a way to promote quality. This section is a mini-manual for the use of HSMS task data in performance evaluation. It shows how the HSMS task descriptions or extended task names can be used to assess whether an institution is achieving its goals, to pinpoint the tasks being carried out below acceptable levels, or to evaluate an individual's performance. The approach

described is generic; however, tasks in diagnostic radiology in Research Report No. 7 are now ready for use.

What Will Be Covered?

The institution must first decide what it wants to evaluate. Does it wish to learn whether the institution or department is accomplishing its goals? Is it to find out how the work in its most important functions is being carried out? Is it to find out how everyone in a given job title is carrying out the work assigned? Is it to find out how specific individuals are doing, such as new employees, newly trained employees, or employees due for review?

If the institution is interested in whether it is accomplishing its goals, a series of preliminary questions have to be answered at the outset. First, the goals themselves must be articulated. Then it must be determined how the goals should be manifested in work. The mere pronouncement of the objectives or goals of an institution is not enough to bring about the performance needed to attain the objectives. The institution must be able to point to the means of achieving the goals through their embodiment in tasks, elements within tasks, or standards of task performance.[6]

If the institution is interested in the overall functioning in a department, it must first know what tasks are being carried out, and then it must decide which of the tasks it wishes to examine and which performers of the tasks it wishes to review.

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[6] Chapter 4 is an example of this type of analysis with respect to quality assurance in diagnostic radiology.

If the institution is interested in examining the work in a given job title it has to know which tasks are being carried out in that title and which tasks and performers it wishes to review. Even in reviewing the work of specific staff, it is necessary to know which tasks are being carried out by the performers who are to be reviewed.

Preparing For Performance Evaluation

To know whether there are HSMS task descriptions to cover all the tasks to be reviewed, the administrator would utilize HSMS task inventories in the manner described earlier in this chapter under the section titled "Using HSMS Data To Structure Jobs." That section describes the creation of task lists by job title and/or employee name.

The output of the first step is a set of HSMS tasks to be included in the review. For each task there should be a list of the names of the employees whose performance of the tasks are to be rated, and the name of one or more individuals who will rate the performers' work from past experience or by observing the individuals at work.

The raters could be supervisors, co-workers, patients, or other persons deemed appropriate given the tasks, or a combination of these. In most cases the performer's supervisor is an appropriate person to evaluate a performer's outputs or task performance because of his or her experience or direct observation. However, the possibility of using patients or co-workers might be considered. If the output is directly consumed by the patient, such as when the task is to give personal care, the patient may be a reasonable judge of the output. In cases where the performer

assists a senior co-worker who is not his or her supervisor, the co-worker may be the best rater of the task's outputs or performance.

The next step is to edit the HSMS task descriptions to reflect actual and/or desired in-house performance for evaluation purposes. Even though the HSMS task descriptions are already written from the point of view of approved procedures, the institution may wish to edit these to conform to actual practice at the institution and the objectives of the review. The institution may wish to address the following questions as a basis for refining the task list:

1. Are the tasks included the most appropriate to accomplish our goals?
2. In each task, is this the way we want to have the task done?
3. If there are choices of procedures, which do we prefer?
4. If there are choices of equipment, which do we prefer or have?
5. What should we be doing that we are not doing?

The output of this step is a set of HSMS task descriptions edited to describe the work as the institution requires it to be done.

Output and Performance Criteria

Each HSMS task description includes a statement naming the output of the task. (It appears in the upper left of the first page of the Task Description Sheets.) A task can have a tangible output, such as a set of radiographs taken during a particular examination. A task can have an intangible output, such as explanation to the patient of how to prepare at home before an examination.

If a task has a tangible output, it should be possible to state concretely the criteria for evaluating the quality of the output. If these output criteria or standards can be stated explicitly, task performance can be evaluated objectively. If a task has intangible outputs, it may be hard to state output criteria. This would be the case when the output cannot be separated from the procedure, such as in giving reassurance, or when largely intellectual processes are involved, such as in diagnosis. In such cases it may be possible to state objective criteria for task performance rather than for the output per se. It may be crucial that all the steps in a task be done correctly in a proper sequence. The absence of a step may be as important as a wrong step. These standards can be termed performance criteria.

The next step in the evaluation process is to go over the tasks to be reviewed and separate those for which objective output criteria can be written from those for which performance criteria will be written. The criteria should then be discussed, written, and reviewed by appropriate expert staff members in the department.

For a task which requires output criteria, the eventual evaluation instrument will need to contain the task reference and the criteria. The extended task name or the output statement on page 1 of the Task Description Sheet is probably sufficient as the reference. Where a task has several outputs, criteria for all may be written, or the most important output and its criteria can be used. For a task which requires performance criteria, the evaluation instrument will need the extended task name as the task reference; depending on the performance criteria, the entire task description or particular elements of the task may also be used to highlight the performance standards.

A decision must be made at this stage whether to assess the performer's work over a past period of time or to have the raters observe the performer during an evaluation period. There are arguments for or against either approach. There are negative aspects to relying on memory, but there are negative aspects to relying on a single example in which the performer may be nervous. The practicability of observation also has to be considered; some tasks take a great deal of time or require that the performer be alone with the patient. The approaches may be combined. The decision should be made by the institution to suit its particular needs.

Rating Instruments

Figure 5 presents an example of what an output or performance rating instrument might be like.[7] There would be one instrument for each task, and as many copies of each as there are raters and performers to be reviewed. The sections to be filled in to fit each task are indicated. The institution may wish to change the language used in this example; however, the instructions should make the following points to the raters:

1. The rater is to keep in mind only the task named, only the criteria mentioned, and only the person being evaluated.

2. For evaluation of past work, the rater's use of the scale involves the rater's judgment of whether the performer meets the criteria, how many criteria are met (if there are several), how often the criteria are met in the usual course of the performer's work, and the degree to which the criteria are complied with.

3. For evaluation of work being currently observed for the purpose of evaluation, all the above considerations must be eliminated and the work being currently evaluated is the only thing that can be considered.

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[7] Figure 5 appears on page 3-39.

4. The rater is to assess the performer's outputs or performance using the criteria as absolutes, and is not to compare the performance or outputs of one performer with those of another in deciding on the ratings.

5. The rater checks a rating value on a nine-point scale whose ratings range from highly unacceptable to much better than acceptable.[8]

The Rating Data

The ratings provide data usable to describe the quality of the task performance in statistical terms. They can be expressed as distributions of superior or inferior performance around scale point 5, which is the minimum acceptable level. The distribution of ratings for each task tells the institution about its overall performance in each task. The distribution of ratings for each performer tells the institution about the competence of individuals. It is then possible to pinpoint problem tasks and problem performers and design remediation through training or reorganization.

When the Output or Performance Rating Sheets have been collected, these should be arranged in sets by task, and arranged within each task set by order of the scale value checked. The results can then be entered in a table similar to that presented in Figure 6. On each row a task's code number and a very abbreviated task name is entered. Column (1) is the total number or ratings for a task. This would be equal to the total number of

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[8] In the section on trainee selection presented earlier in this chapter a similar scale for rating is presented. It differs with respect to the reference. The earlier one compares the performer with others in the title. The one here compares the performance with absolute criteria. The reason for the difference is that one must assume a normal distribution of ratings for predictive purposes. When absolute standards are involved, skewed distributions can be expected. For evaluation of institutional performance, the skewness of the distribution is of interest and is desirable if it is a positive skewness.

Figure 5. SAMPLE OUTPUT OR PERFORMANCE RATING INSTRUMENT

p. 1 of 2

GENERAL INSTRUCTIONS

You are being asked to consider the work activities of one or more persons employed in this institution. Each work activity, called a task, will be summarized for you on one of the following pages, along with the name of the person whose work you are to consider. You may be asked to consider the work of more than one person doing the same task, and/or more than one task done by the same person. However, there is a place for you to indicate that you do not feel that you have enough information to rate the person or the work represented by the task named.

Your ratings will make an important contribution to determining the current general level of performance in the task being rated. These ratings can be used to help plan for improvement of work performance.

The task statements will each be accompanied by a statement of what qualities are considered desirable with respect to the outputs which result from the task (the task output criteria), or by a statement of what performance standards are desirable with respect to how the task is carried out (task performance criteria). Several criteria may be mentioned.

You are being asked to consider only the task as summarized, only the person doing it as named, and only the criteria given.

If you are asked to consider work carried out over a past period of time, please consider how many of the criteria are met, to what degree they are met, and how often they are met by the person named, over that period of time. You should then check off the statement that best describes your evaluation.

If you are asked to evaluate work you are currently observing, please consider how many of the criteria are met and the degree to which they are met only in the work you are currently observing. Then check off the statement that best describes your evaluation.

Try to be fair, objective, and impartial in your ratings. Base your ratings on the employee's attainment of the criteria for the task named and not on any personal characteristics which he or she may have; do not compare this person's performance or outputs with those of others. Please do not let your evaluation of this person's performance in one task affect your judgment of how another task is done by the same person.

Please fill in your name and title wherever it is called for.

Thank you very much for your cooperation.

Figure 5. SAMPLE OUTPUT OR PERFORMANCE RATING INSTRUMENT (continued)



OUTPUT OR PERFORMANCE RATING SHEET

1. Please enter: Your Name _____ Title _____

2. You are asked to consider the following task: (Code No. - - - - - - -)

[Institution fills in the task code number (above) and in this space enters the extended task name. Institution may also wish to name the task output(s).]

3. You are asked to consider employee: _____ (Name)
_____ (Title)

4. Do you feel qualified to evaluate the quality of this person's work performance in this task? .... ( ) Yes; .... ( ) No. If no, please go on to next task. If yes, please go on to item 5.

5. Please consider the criteria to use to evaluate the task's output or the performance of this task:

[Institution fills in the output or performance criteria.]

6. You are being asked to evaluate the performance or output of this employee in one of the following ways:

( ) Consider the employee's work over a substantial and representative period of time; do not concentrate on very recent experiences or only on outstanding examples of achievement or failure.

( ) Observe the employee at work currently.

[Institution selects one or both.]

7. Please rate this employee according to your judgment of the degree to which he or she meets this task's output or performance criteria. How many criteria are met, and how well are they met? Please check the statement that best describes your evaluation:

9...( )...Distinctly superior with respect to criteria.
8...( )...Considerably above acceptable with respect to criteria.
7...( )...Moderately above acceptable with respect to criteria.
6...( )...Slightly above acceptable with respect to criteria.
5...( )...Acceptable with respect to criteria.
4...( )...Slightly below acceptable with respect to criteria.
3...( )...Moderately below acceptable with respect to criteria.
2...( )...Considerably below acceptable with respect to criteria.
1...( )...Distinctly inferior with respect to criteria.

Figure 6. SAMPLE HEADING FOR TABLE OF OUTPUT OR PERFORMANCE RATINGS BY TASK

| Task Name (Abbreviated) | Task Code No. | Total Task Ratings (1) | Ratings of Performance by Task | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Number of Output or Performance Ratings by Scale Value (2) | | | | | | | | | Percentage Distribution of Ratings by Scale Value (3) | | | | | | |
| | | | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| | | | | | | | | | | | | | | | | | | | | |

Figure 7. SAMPLE HEADING FOR TABLE OF OUTPUT OR PERFORMANCE RATINGS BY EMPLOYEE

| Employee Name and Job Title | Total Empl. Task Ratings (1) | Ratings of Performance by Employee | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Number of Output or Performance Ratings by Scale Value (2) | | | | | | | | | Percentage Distribution of Ratings by Scale Value. (3) | | | | | | | | | |
| | | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| | | | | | | | | | | | | | | | | | | | | |

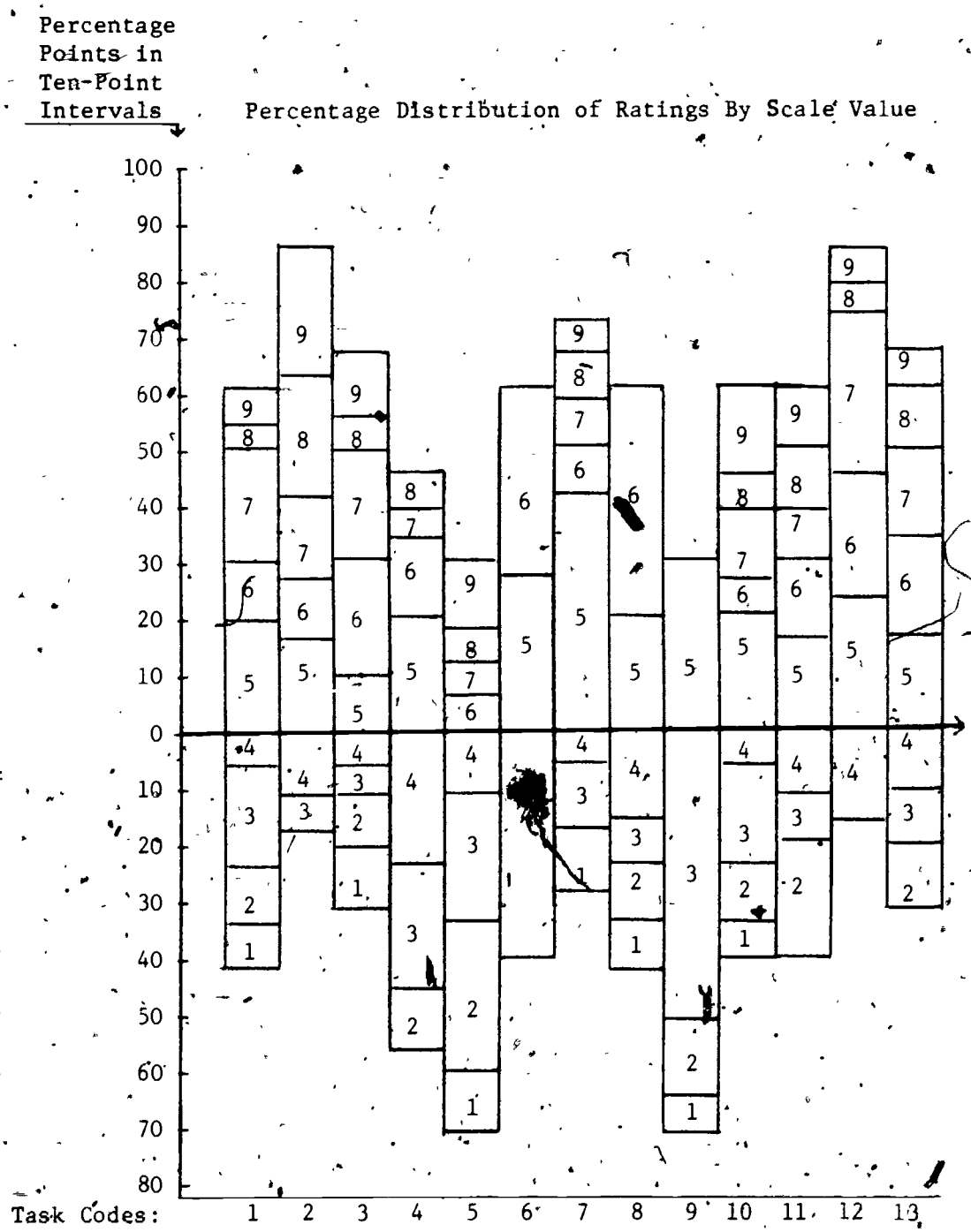
performers being rated on the task. (If performers receive ratings by several raters it might be necessary to first average all the ratings for a given performer.) In column (2) there are sub-columns, one for each scale value. For each task, the number of ratings at each scale value is entered. (Their sum should equal the figure in column (1).) Column (3) is the percentage distribution of the scale values. It is necessary to do percentage distribution so that comparisons can be made from task to task. (The percentage distribution is obtained by dividing a given entry in a sub-column in (2) by the total figure in column (1), and multiplying by 100.)

A similar table can be made that shows the ratings for employees. In Figure 7, each row refers to an employee. Column (1) is the total number of tasks on which the employee has been rated. Columns (2) and (3) now refer to the distribution across employees.

The institution is now in a position to judge which tasks are being performed at acceptable levels, and to what extent. Ratings at scale points 1 to 4 fall below acceptable levels. Ratings from 5 to 9 are at or above acceptable levels. The institution can now decide what level of achievement it wishes to attain, and what type of distribution for a task warrants the task being considered a "problem task."

Figure 8 represents a graphic portrayal of a hypothetical distribution based on column (3) of Figure 6. The distribution represents hypothetical data for thirteen tasks whose code numbers are listed along the bottom horizontal axis.

Figure 8. HYPOTHETICAL GRAPHIC REPRESENTATION OF DISTRIBUTION OF OUTPUT OR PERFORMANCE RATINGS BY TASK




Each bar represents distribution within one task. Numbers within bars represent the scale value which the area represents. Areas are percentages as read on the vertical scale.

Each bar represents a task. Each vertical division on the left-hand vertical scale represents ten percentage points. Within each bar, the percentage distribution of the ratings for a task are laid off by scale value. Rating scale values starting from the value of 5 are laid out above the zero line and move up to 9; the scale value of 4 is laid out below the zero line; others follow down to 1. The number that appears in an area within a bar indicates the scale value represented by the area in which the number is found. Laid out this way, the area above the zero line shows the percentages of the tasks at acceptable ranges, and the area below the zero line shows the percentages of the tasks at unacceptable ranges.

The institution can now see that a task such as Task 6, while having a 40 percent distribution below the "acceptable level," has none below the rating of 4, "slightly below acceptable." Any task with as much as ten percent of its ratings at 1, "distinctly inferior" might be in trouble. Task 5 is such a task. Tasks 6 and 8 have no ratings above 6, "slightly above acceptable," and that might be of concern. The clearest problem task is Task 9, with 70 percent of its outputs "moderately below acceptable" or worse, and none better than "acceptable."

A similar visual presentation can be prepared for the employee data. In such a case the bars would refer to employees rather than tasks, and the distributions would indicate performance ratings across the tasks of the performer's job. Once the "problem tasks" or "problem employees" are located, it becomes possible to diagnose what it is about the quality of the performance or of the output that has given rise to the inadequacy of the results. Then remediation can be planned.

# CHAPTER 4

## A PROGRAM OF QUALITY ASSURANCE, SAFE PRACTICE, AND HEALTH PROTECTION

### INTRODUCTION

A quality assurance program in diagnostic radiology would involve policies, procedures, and activities to promote radiation health protection and safe practice while providing high quality diagnostic results. This chapter is written for the administrator of a hospital or a department of diagnostic radiology who is interested in using HSMS data to set up or evaluate such a quality assurance program. It is also directed to the educator who is interested in promoting quality assurance through curriculum objectives, and for the consumer who wishes to know what safe practices to require as a part of the radiography services he or she purchases.

The director and staff of the Health Services Mobility Study do not claim to be experts in radiology, radiologic technology, or radiation health protection. However, during the past four years, our work has brought us into direct contact with professionals and government personnel who are concerned with these issues, and we have become aware of the activities and policies that could bring about an improvement in quality and safety in diagnostic radiology. We have obtained an overview of many of the issues involved. We offer a series of suggestions in this chapter in the hope that they can prove helpful to institutions, practitioners, and patients. The HSMS data are offered as an objective frame of reference which the administrator, educator, or consumer can use to create or evaluate a quality assurance program.

The first section of this chapter presents an overview covering the policies, planning, and practices that are required for a program of quality assurance in diagnostic radiology. The second section shows how the policies can be expressed as jobs, tasks, and task elements to bring the program to life. The third section indicates how a quality assurance program would be reflected in curriculum objectives and presents selected excerpts from HSMS curriculum objectives. The fourth section offers some comments on other safe practice features in patient care and activities that relate to patients' rights and dignity. The last section suggests some minimum requirements which a consumer may wish to check on before purchasing diagnostic radiology services and suggests some basic patient rights in this area.

## ISSUES, POLICIES AND PRACTICES

Current legislation in the area of radiation health protection reflects both public and private concern with safe practice in the use of ionizing radiation.[1] However, the requirements deal primarily with equipment conformance standards; additional policies are needed if safety consciousness is to be translated into safe practice. The Bureau of Radiological Health, Food and Drug Administration, has indicated that, in spite of improvements in the safety and efficiency standards set for medical x-ray equipment, actual exposure delivered to the patient remains very much under the control of the equipment operator. We might add that it also remains very much in the hands of the policy makers who direct the equipment operator.

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[1] Title 21, Food and Drugs; Subchapter J: Radiological Health; Part 1020: Performance Standards for Ionizing Radiation Emitting Products.

A program for radiation health protection that is genuinely dedicated to minimizing radiation exposure to persons and staff cannot exist without a commitment by the institution as a whole. An overall program is needed and must include prescriptions for the way patients are referred, screened, and approved for radiographic examinations, the way records of examinations are made and kept, and the ways in which examinations are conducted. An overall program requires planning, because a series of monitoring functions must be set up, carried out regularly, evaluated, and followed up. X-ray equipment must be test regularly and calibrated; patient exposure rates must be monitored; personnel exposure must be recorded and reviewed; film processors must be monitored; and unnecessary exposure must be noted and eliminated. This means that other departments in the hospital, such as the emergency room and the personnel department must be involved. It means that patient admissions and screening, procurement, and administration policies could be affected; it means that staff could need retraining; it means that the department might have to change some of the ways it functions.

If an institution is interested in a quality assurance program, its policies must be articulated. It is then important to indicate how these are to be manifested in work. We present some suggestions at the policy level which we believe must be adopted if a successful program is to be instituted. They are listed with few professional arguments to support them because most of the scientific rationale has long since been articulated by experts. The list of suggestions can serve as a check list for the administrator who is reviewing an ongoing program.

Requisitions and Screening

Patients should never be subjected to automatic orders for routine radiographic screening. Every radiograph ordered should be justifiable from the patient's presenting condition. This means that, on a policy level, there should be a triage function in the admitting or emergency room that applies to x-ray requisitions.

Female patients of reproductive age should be routinely asked for information on their menstrual cycles and should be personally questioned by physicians and/or technologists so that any possibility of exposing a fetus is known or ruled out,

Patients should not be subjected to special radiologic procedures simply at the request of a clinician. The department of radiology or other specialty departments in the hospital should screen requests so that unwarranted or questionable requests for procedures may be reviewed, alternatives suggested, and the patient spared unnecessary radiation exposure.

It might seem wasteful to use radiologists' time in "consultation tasks," but by eliminating unwarranted requests, the number of procedures actually carried out could be reduced; as a result, the costs of health care could be reduced.

It might be argued that over-prescription of x-ray examinations is a form of defensive medicine in the face of increasing numbers of malpractice suits and the rising cost of malpractice insurance. This author suggests in answer to the argument that unjustifiable exposure to ionizing radiation can open up a hornets nest of malpractice suits as the public be-

comes more sophisticated about the dangers of unnecessary radiation exposure. The requirement for a consultation decision for x-ray requisitions is comparable to a second opinion for surgery now being seriously considered all across the country. This is a defense against malpractice suits.

Shielding

Some radiation exposure to the gonads comes about due to unanticipated angles and positions that bring the gonads into the path of the x-ray beam. The technologist should not have to second guess this all the time. Gonadal shielding should be routinely provided to all patients unless it interferes with the examination. If the technologist were to provide gonadal shielding routinely, and only had to consider when it is not appropriate to provide it, patients could be spared the exposure due to neglect or shortsightedness.

Alternatively, or as a second precaution, department staff should decide on the appropriate shielding to use for specific examinations and patient positions by age and sex. These should be listed on technique charts and be used as routinely as the selection of technical exposure factors.

Examination Procedures

Radiologists should carry out or order examinations using the minimum number of exposures and the least total exposure compatible with the attainment of diagnostic quality information. Technologists should collimate to the area of interest and not rely on automatic collimation. Automatic collimation does not provide protection when the size of the cassette is too large or the area of interest takes up less than the space available on the surface of the x-ray film.

Patient Records

Patients should routinely be given records of their radiographic histories. These should include the type of examination, the date, the estimated radiation exposure to the area of interest and/or the gonads (including exposure from "rejects"), and the whereabouts of the radiographs. This would make it possible for patients to inform physicians in private practice or in hospitals of their exposure histories.[2] Unnecessary duplication of examinations could be avoided; at least the new physician would be aware that when he or she was ordering a new set of radiographs, other radiographs exist. There would be information on when they were taken, and the physician could consider the implications of having more radiographs made; the earlier ones could be used for comparison purposes.

Equipment Calibration and Exposure Records

There is no way to record or account for patient exposure unless patient exposure rates under standard conditions are known and the machines are calibrated to provide a known output in standard circumstances (i.e., to provide known dosage for given radiographic parameters). As a result of periodic tests of the equipment, it should be possible for the technologist to estimate and record patient exposure by referring to posted exposure rates or dosages. At the time of billing, the patients' radiographic histories could be copied by clerical staff from the charts and given to patients routinely. Patients would then have information on their examinations and on their cumulative radiation exposure.

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[2] The use of a central information repository or the giving of the radiographs to the patient are less attractive alternatives. The former touches on the fear of too much centralized record keeping; the latter is not practical.

## Film Processors

The monitoring of film processors is an essential part of any quality assurance program. There is no point in calibrating the x-ray machine to provide uniform doses if the radiologist thinks he or she must increase the kVp because of dissatisfaction with the images being produced. All too often the fault is with the film processor, and a few simple adjustments in the darkroom could reduce the patient exposure required for a given standard of diagnostic quality.

## Review

A serious program to promote safe practice and quality must include the regular review of radiographs and diagnoses. Radiographs should be reviewed for diagnostic quality, evidence of minimum collimation, and proper shielding. Accepted and rejected radiographs should be evaluated as a check on unnecessary "retakes" or incipient problems with staff or equipment. Diagnoses based on radiography should be compared with later pathology and/or autopsy reports with a view toward eliminating unnecessary examinations and improving diagnostic accuracy.

## Overall Planning

If there is to be a program in quality assurance, every staff member and all equipment must be involved. One or more staff members should be responsible for designing, directing, and periodically evaluating the quality assurance program. The director should train or retrain staff to carry out the program, should periodically review and revise the program in the light of its results and as new information on safety and equipment appears, and should keep staff informed of what they must know to adapt to changes or handle problems.

## HSMS QUALITY ASSURANCE DATA

The HSMS recommended job structures, task identifications, task descriptions, skill and knowledge data, and curriculum objectives all provide concrete ways in which to bring a quality assurance program into being. We present these data by reviewing the job structures and tasks for the radiation physicist and quality assurance technician. Then we discuss the tasks and task elements of the radiologist and radiologic technologist that reflect quality assurance standards.

### Job Structures for Quality Assurance

The radiation physicist is the likely professional to head a quality assurance program if he or she is sufficiently trained in the procedures involved and in radiobiology. Passion for patient and staff safety is needed to challenge radiologists and technologists on their practices, and a comprehension of diagnostic objectives is necessary for intelligent planning. The director of a quality assurance program has to be an educator and a watchdog.

The radiation physicist is assigned the tasks of developing and evaluating quality assurance and radiation health protection programs, carrying out professional quality assurance functions, and teaching radiation health protection physics and safety procedures. The detailed description of such tasks appear in Research Report No. 7, Volume 3.[3] The tasks are listed below by abbreviated task name and Code Number. They are also listed in Appendix E, Table E.1.

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[3] Op. cit., Chapter 3.

Program Planning and Evaluation Tasks

Task 528 Designing, maintaining, evaluating calibration and/or dose monitoring program in diagnostic radiology.

Task 546 Designing, maintaining, evaluating radiation protection and monitoring programs in diagnostic radiology.

Task 542 Designing, maintaining, evaluating darkroom and/or film processor monitoring program in diagnostic radiology.

Quality Assurance Procedure Tasks

Task 541 Evaluating accepted and rejected radiographs to identify any technical problems with staff functioning, equipment, radiation protection.

Task 555 Investigating reasons for reported high occupational radiation exposure and initiating remediation.

Task 557 Collecting and presenting technical information about and/or recommending new diagnostic x-ray equipment.

Task 547 Determining primary and secondary structural shielding required for diagnostic x-ray installations.

Quality Assurance Education Tasks

Task 558 Providing clinical training for staff in a diagnostic radiology department in quality assurance tests of equipment, in radiation protection procedures, and related maintenance.

Task 560 Preparing lectures or participating in meetings of staff members in diagnostic radiology on radiation protection and quality assurance requirements and practices.

Task 559 Planning and presenting lectures and/or related laboratory sessions on radiation and/or health physics for students in professional programs for diagnostic radiology, in medical school, or in medical sciences.

The tasks of the quality assurance technician and some of the tasks of the quality assurance aide are generated by the planning tasks in a quality assurance program. The task names provide a check list of most of the quality and safety activities that seem to be regarded as essential

for optimal practice.[4] The tasks include safety checks on the functioning of equipment, collection of test data for the selection of proper shielding for patient examinations, and test data for the safe deployment of staff. Performance of the tasks makes possible a feedback monitoring system that would provide indications of when there might be trouble with equipment before patients or staff are exposed to unnecessary radiation.

The quality assurance technician task descriptions are in Research Report No. 7, Volume 3. They include Task Codes 78, 173, 175, 178, 187, 276, 280, 523 through 525, 527, 529 through 540, 543 through 545, 548 through 550, 553, 554, and 556. Their abbreviated task names are listed in Table E.1 in Appendix E, and in Curriculum Objective 349 in Chapter 9 of Volume 2 of this report. The radiation protection tasks of the quality assurance aide are Tasks 70, 167, 192, 273, 551, and 552. (The aide has other tasks as well.) The task descriptions are also in Volume 3 of Research Report No. 7; the abbreviated names appear in Table E.1 and Curriculum Objective 348.

Tasks of the Radiologist and Radiologic Technologist

We have included consultation tasks for most radiology specialties so that unwarranted or questionable requests for procedures may be reviewed, alternatives suggested, and the patient spared unnecessary radiation. If such "deciding and/or approving requests for procedure" tasks were done

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[4] There is a good deal of disagreement about which tasks must be done in-house to meet legislative and institutional requirements for safe practice and to provide optimal diagnostic results with minimum radiation exposure to patients and staff; the HSMS task descriptions provide a cross-section of tasks that would be generated if a quality assurance program were carried out; they are not exhaustive or free from controversy.

elsewhere in the institution, such as in clinical specialty departments, the tasks would be the same. Regardless of where this process takes place, in the radiology department or prior to referral, we feel that these are important quality assurance tasks. (The issues involved were presented earlier in this chapter.)

The task descriptions for radiologists' consultation tasks appear in Volume 1 of Research Report No. 7 (Task Codes 311, 314, 328, 331, 333, 339, 396, 409, 418, 421, 441, and 469). Task 394 in Volume 1 provides a check of diagnostic quality: "Comparing prior radiographic diagnoses with later pathology and/or autopsy reports and reporting discrepancies to appropriate radiologists." Task 439 in Volume 3 provides for inputs from the radiologist in the selection of technical factors: "Ordering or approving changes in technical factor selector settings to compensate for a change in quality of x-ray machine output."

The radiologic technologist has a quality assurance task in which the technologist evaluates his or her own radiographs or those of other technologists when the radiologist will not be present to provide such a review. The task description of Task 81, "Providing technical quality review of 'plain film' radiographs," appears in Volume 2 of Research Report No. 7.

Radiologists and radiologic technologists have task descriptions which provide for discussion of quality assurance issues and policies within departmental meetings. These are Task 326 for the radiologist (in Volume 1) and Task 352 for the radiologic technologist (in Volume 2). Radiologists and radiologic technologists have tasks in which they wear and periodically replace dosimetric badges as part of an exposure moni-

toring program. These are Task 280 (for the radiologic technologist and the two technicians) and Task 327 (for the radiologist). These tasks appear in Volume 3 of Research Report No. 7.

Task Elements

There are elements within each of the task descriptions of the radiologists and the radiologic technologists that reflect the requirements of a quality assurance and radiation protection program.

In radiologist examination tasks, we include a check that rules out known or possible pregnancy for female patients of reproductive age, and a check of proper shielding of the patient and anyone to remain in the room during the exposure to radiation. We have the radiologist using shielding personally. We have the radiologist consider the patient's radiation exposure history when deciding to order additional exposures or a change in technical factors.

The radiologic technologist examination tasks have the radiologic technologist review the x-ray requisition to check on the patient's condition, possible allergies, possible extensive cumulative exposure, or recent duplication of the present examination ordered. We have the technologist measure the patient before selecting technique, check personally on possible pregnancy, and consider and supply appropriate shielding to the patient and to anyone else who is to remain in the room during exposure. We have the technologist collimate to the area of interest, not just to the size of the film. We have the technologist consciously notice radiologists' preferences on contrast and density to avoid retakes. We have the technologist record exposure dosage when the institution provides and posts such information.

## CURRICULUM OBJECTIVES FOR QUALITY ASSURANCE

It is not enough to have desirable task descriptions to bring about desirable practice. It is also necessary to teach such practices so that the skills, knowledges, and procedures needed to perform the tasks as described are transmitted to the staff member or the student.

Chapter 9 in Volume 2 of this report includes curriculum objectives for the radiologic technologist and quality assurance technician. Many of these incorporate the behaviors, skills, and knowledge categories that are essential to a quality assurance program. This section offers excerpts from some of the curriculum objectives as an example of what can be done to pinpoint and make explicit desirable work performance and curriculum content. (The Curriculum Objective Number for each excerpt is given so that the reader can refer to the full curriculum objective in Chapter 9.)

### Quality Assurance Technician

#### Written Use of a Relevant Language (Skill)

Preparing a report for use by personnel such as radiologists, technologists, or nurses indicating the safest positions for personnel who must remain in room during radiographic or fluoroscopic examination based on results of survey (Curriculum Objective 70).

Writing a letter arranging an interview for a staff member who has a high radiation exposure incident or has a high cumulative dose level (Curriculum Objective 70).

#### Decision Making on Methods (Skill)

Selecting appropriate test procedures and sequences based on options available, type of equipment, and other tests to be run on diagnostic x-ray equipment (Curriculum Objective 84).

Decision Making on Quality (Skill)

In testing x-ray equipment, or film, or film processors, or calibrating quality assurance test instruments, being careful to select appropriate test procedures for the equipment involved, carry out each test step carefully, record results accurately, assess results conscientiously, and discuss results with supervisor and/or radiologist in charge so as to assure that patient exposure is minimized, diagnostic reliability is provided, and legal requirements are met (Curriculum Objective 103).

In monitoring patient exposure rates for routine diagnostic x-ray procedures, carrying out procedures carefully and accurately; recommending how to use gonadal shielding; helping to use results to make it possible to record cumulative patient exposure (Curriculum Objective 103).

In conducting radiation protection survey, carrying out procedures carefully and accurately; evaluating results conscientiously; using results to suggest the safest positions in room for personnel who must remain during exposure; suggesting corrective measures (Curriculum Objective 103).

Radiobiology (12210000)

In testing x-ray equipment, film processors, and x-ray films for conformance to radiation protection standards, conducting radiation protection survey, or calibrating test instruments, understanding the effects of ionizing (x-ray) radiation on human organisms sufficiently to conscientiously apply tests and evaluate conformity with safety requirements; being able to use details about the effects of ionizing (x-ray) radiation on human tissues to discuss results of tests, such as effect of problems and deviations from acceptable standards on patient exposure (Curriculum Objective 279).

In monitoring patient exposure rates for routine diagnostic procedures, being able to use understanding of the effects of ionizing radiation on human organs and tissues, and use details about safety requirements to conscientiously carry out the monitoring tests and consider the tissues and organs involved in the various radiographic or fluoroscopic examinations; being able to determine whether procedures being tested meet acceptable exposure standards for the area of the body involved; being able to recommend gonadal shielding appropriate for particular examinations and positions, consider the effect of collimation, and discuss and explain the effects of any problem or deviations from acceptable standards on patient exposure and safety (Curriculum Objective 281).

Diagnostic Radiography (12223000)

Using an understanding of diagnostic radiography and appropriate details about diagnostic x-ray equipment, technical factors, controls, test materials, collimators, and the interpretation of radiographic images to carry out tests of x-ray equipment by setting x-ray tube at appropriate test heights, using light system, collimators, setting technical factors, preparing test films, using test objects, making test exposures, interpreting test images (Curriculum Objective 290).

Using an understanding of diagnostic radiography and appropriate details about a variety of diagnostic x-ray equipment, film processors, x-ray film, and special test equipment (such as test top, penetrometer, beam attenuators, test bar or star patterns, pin hole diaphragm, pulse counter, chronometer, oscilloscope, radiation detection device, phantoms, survey meter, kVp, mA, mAs measuring instruments, graph paper, penetrometer test cassettes, ionization chamber, electrometer, filters, sensitometer, radioactive source, TLD packets) to carry out tests of x-ray equipment (Curriculum Objective 290).

Interaction With Radiation (15222500)

Taking account of details of x-radiation properties such as scattering, the qualities of radiolucent and radiopaque materials, absorption and density properties of matter to carry out tests of x-ray equipment involving exposure of test films, masking of areas of test films, and attention to personal safety (Curriculum Objective 330).

Applying details about the properties and behavior of electromagnetic ionizing radiation such as x-rays in interaction with living tissue (transfer of energy from the radiation to molecules of the cells) and with other forms of matter (such as attenuating material to reduce the exposure rate of a beam of radiation) to be able to use test equipment such as radiation detection devices appropriately, to understand and explain the effects of deviations from acceptable safety standards for x-ray equipment on patient exposure and the quality of the radiographic image (Curriculum Objective 330).

Radiologic Technologist

Decision Making on Methods (Skill)

Deciding on accessory equipment, technical factors, shielding and immobilization equipment appropriate for patient's age, sex, size, condition, and the examination ordered; deciding whether to order isolation procedures (Curriculum Objective 85).

Deciding whether any exposures can be eliminated, whether patient can be examined in the standard positions called for, or whether to substitute alternative positions to achieve the same projections and accomplish the purpose of the examination (Curriculum Objective 85).

Decision Making on Quality (Skill)

In taking radiographs of patients, taking care to review requisition and patient information for possible insufficiency of information, contraindications, or anything else that should be brought to attention of radiologist; taking care to check on materials and equipment and set up before having patient enter examination room; checking contrast media for chemical deterioration; taking care to measure patient with calipers to select appropriate technical factors; selecting minimum exposure compatible with diagnostic quality; taking care to adjust technical factors for special considerations of patient's size, condition, the use of magnification, or posted changes; taking care to supply shielding to patient's gonads and radiosensitive areas; supplying shielding to any staff who will be present during exposure; collimating to area of interest; making note of radiologist's density preferences or equipment problems to avoid need to redo examinations; making sure that any "retakes" ordered are for medical-diagnostic purposes (Curriculum Objective 99).

In assessing the technical quality of "plain film" radiographs, being careful to take account of the purpose and type of study, appropriate diagnostic standards, evidence of proper collimation and use of shielding; being careful to order retakes only if medically warranted; explaining problems carefully so as to instruct technologist whose work is being reviewed (Curriculum Objective 104).

Implicative Skills

Concluding whether radiographs demonstrate that correct patient positioning, collimation, and shielding have been accomplished, and whether the radiographs demonstrate the area and condition of interest satisfactorily for diagnostic purposes based on review of requisition and examination of radiographs; concluding whether problems are due to technologist's performance, malfunctioning of x-ray or processing equipment (Curriculum Objective 127).

Concluding whether there are possible contraindications to a radiographic examination that should be brought to radiologist's attention, such as possible exposure of fetus, recent duplication of examination, or specific patient con-

ditions, based on reading patient's medical-technical history, requisition sheet, observation and/or interview with patient and signs of distress, adverse or emergency reaction (Curriculum Objective 127).

### Radiobiology (12210000)

In providing technical quality review of "plain film" radiographs, being able to use understanding of the effects of ionizing radiation on human organs and tissues and use details of biological safety requirements and protection procedures to conscientiously review whether a needlessly large area of patient's body has been exposed, whether there is visual evidence of proper field size collimation, use of appropriate shielding; in ordering "retakes," restricting orders to those only for medical reasons, such as for missing areas or views or those needed to complete diagnostic information; being able to explain to technologist reasons for decision (Curriculum Objective 282).

In taking radiographs or participating in radiographic or fluoroscopic examinations, being able to use understanding of the effects of ionizing radiation on human organs, tissues, and genes, and use details of biological safety requirements and protection procedures to conscientiously select appropriate shielding for patient based on area of interest, patient's age, sex, and views ordered, especially gonadal shielding; being able to apply shielding to radiosensitive tissues that will be in the primary path of the beam but not part of area of interest (Curriculum Objective 282).

Being able to check records and/or interview female patient about possible pregnancy to be sure that there is no danger of exposing a fetus, check that examination is not a duplication of one taken in the recent past, or bring to attention of radiologist an unusually high history of radiation exposure (Curriculum Objective 282).

### Diagnostic Radiography (12223000)

Applying an understanding of diagnostic radiography to obtain the requested views of the area of interest and condition being investigated by means of patient positioning, centering, placement, angulation and centering of x-ray film, height, angulation and centering of x-ray tube, use of immobilization devices, use of light system, use of collimators; being able to select alternative positions for the same views to accomodate special problems with patient's mobility; being able to select size of film, cassette or film holder, type and speed of film as appropriate for examination (Curriculum Objective 293).

Applying an understanding of diagnostic radiography to select technical exposure factors for radiographic examinations or fluoroscopy using technique and tube rating charts; being able to take account of thickness of the body part, whether fatty or muscular, patient's age, collimated field size, use of accessories such as grid, bucky, intensifying screens, the type and speed of film, focal-film distance, presence of pathological condition, cast, preference of radiologist, posted changes in output, or conversions needed for use of magnification technique (Curriculum Objective 293).

Interaction With Radiation (15222500)

Understanding and applying details about the properties and behavior of electromagnetic ionizing x-radiation in interaction with living tissues including scattering, the attenuating properties of materials, and the effects of technical exposure factors, distance, and field size to provide diagnostic quality radiographs most safely, or give proper assistance during diagnostic examinations involving x-rays; being able to understand the reason for and provide minimum exposure compatible with diagnostic quality images when selecting or converting exposure factors; being able to understand the reason for and provide collimation to the area of interest, appropriate shielding to patients and personnel (Curriculum Objective 331).

Understanding and applying details about the attenuation properties of materials in interaction with x-radiation, the qualities of radiolucent and radiopaque materials, absorption, and density to appropriately select technical factors for radiographic examinations according to the nature of tissue (such as fatty or dense), whether contrast media is being used; being able to judge when objects or substances on the patient's body must be removed or taken account of in the selection of technical factors or in positioning (Curriculum Objective 331).

OTHER SAFE AND HUMANISTIC PRACTICES

There are other important practices in a department of diagnostic radiology that must be considered in a thorough quality assurance program. These practices relate primarily to patient care issues such as protection against contamination and infection, provisions against accidents, emergencies, injuries, and adverse reactions to drugs. They also include practices that reflect a growing demand that the patient be regarded

as the center and star of the health services delivery system. We assume that the patient's well-being is the reason that health services are delivered, and that the patient's dignity and rights are to be safeguarded.

Policies and Practices

We subscribe to the American Hospital Association's Bill of Rights for Patients. These include the right of the patient "to receive from his physician information necessary to give informed consent prior to the start of any procedure and/or treatment." Whenever an introductory technique is involved we have the radiologist check for or obtain informed consent, although this is not currently required by law everywhere. In all our task descriptions we have the performer reassure the patient and explain what is happening and what will happen. We agree that "the patient has the right to considerate and respectful care."

The patient care tasks for all job titles reflect standards of safe practice. For example, whenever there is a puncture procedure we have the performer applying pressure to the puncture site to prevent hematoma. The task descriptions pay attention to sterile technique and isolation or decontamination requirements, and include checks on the expiration dates and appearance of drugs and contrast media. We provide checks of patient allergies, attention to patients' response to the procedures; we have performers inform patients of drug contraindications and side effects. We include emergency care and first aid tasks.

We have the radiologic technologist consider the movement of which the patient is capable, arrange to have the patient attended,

cleansed, and taken to the next location when appropriate. The radiologic technologist always checks the patient's identity against the requisition sheet; we always have a check that medications such as sedatives or analgesics are allowed time to take effect before the procedure begins.

Excerpts from Curriculum Objectives

This selection of excerpts from HSMS Curriculum Objectives may give the administrator, educator, or consumer some idea of how a safe practice and humanist policy can be manifested in task behavior.

Human Interaction Skills

Explaining to patient name and purpose of medication to be taken orally or injected and possible side effects; asking about allergies; injecting or administering medication (patient care technician; Curriculum Objective 27).

Explaining to patient and/or accompanying family member what will be involved in the procedure; indicating the types of positions the patient will be asked to assume and the cooperation that will be asked of the patient; answering patient's non-medical questions honestly; attempting to reassure patient and develop confidence (radiologic technologist; Curriculum Objective 34).

Decision Making on Quality (Skill)

In taking radiographs of patients, taking care not to move patient in any way that might be harmful, painful, or needlessly uncomfortable; selecting alternative position if appropriate; taking care to handle IV drip, oxygen supply or catheters with care; assisting patient; being alert to any signs of pain, adverse reaction to procedure, contrast medium; taking care not to leave patient unattended or liable to fall off table (radiologic technologist; Curriculum Objective 99).

Implicative Skills

Concluding whether medication type or dosage ordered is inappropriate, has already been administered, may be in error or

contraindicated for patient; deciding whether to refuse to inject (patient care technician; Curriculum Objective 120).

Concluding whether patient is having an adverse or emergency reaction to procedure or contrast medium, or is showing signs of distress, or needs readjustment of life support equipment; concluding which staff member to notify (radiologic technologist; Curriculum Objective 127).

Various Knowledge Objectives

In taking radiographs, being able to use details about the way conditions of shock or trauma manifest in the patient so as to properly move and care for patient, position and immobilize safely, recognize emergency signs, and select technical factors; being able to recognize shock reaction in patient (radiologic technologist; Curriculum Objective 219).

In taking radiographs, being able to use details about the proper way to handle and transport sick or wounded patients so as to properly assist or transfer patient to or from wheelchair, stretcher, examination table, lavatory, determine when to request assistance in moving patient, and to position and immobilize patient so as to avoid injury or unnecessary pain, based on the patient's age and condition (radiologic technologist; Curriculum Objective 254).

In preparing patient or materials for radiography involving surgical or introductory procedures, being able to apply information about asepsis to decide whether to arrange for or carry out isolation or decontamination techniques, arrange for proper clean-up of patient and/or equipment after the examination, arrange to have dressings reinforced or reapplied so as to keep patient, equipment, and area free of contamination (radiologic technologist; Curriculum Objective 274).

In preparing patient for iodine based contrast study, applying information about drug allergy to question patient or accompanying adult about allergy to shellfish or past adverse reactions to contrast medium, especially iodine based; observing patient for signs of allergic reaction such as severe flushing, salivation, choking, vomiting, pallor, fainting, or shock (radiologic technologist; Curriculum Objective 299).

In administering medication subcutaneously, intramuscularly, or orally, applying information about drug synergism to question patient, review information, and consider whether patient's use of other drugs suggests a contraindication to administration of prescribed drug, or to explain possible synergistic side effects to patient (patient care technician; Curriculum Objective 302).

In administering a drug to act on the neuromuscular system subcutaneously or intramuscularly, being able to explain the name and purpose of the medication, possible side effects, contraindications; being able to consider whether dosage is appropriate (patient care technician; Curriculum Objective 322).

In preparing for a radiographic examination, being able to recognize when a patient's record calls for prior sedation or any other drug acting on the central nervous system, and checking or allowing for a proper elapse of time for the medication to take effect; being able to take account of effects of sedation on the patient's behavior and state of awareness (radiologic technologist; Curriculum Objective 323).

In taking radiographs or providing technical assistance during fluoroscopic examinations or angiography involving patients who are or may be terminally ill, being able to apply information about the behavior and emotional state of such patients in order to reassure, assist them during the procedure, treat them with sympathy, dignity, and understanding; being able to recognize negative, withdrawn, frightened, or irrational behavior as part of the process so as not to take this personally; being able to treat the patient with dignity and concern regardless of the patient's behavior (radiologic technologist; Curriculum Objective 337).

Evaluation

A list of tasks in quality assurance and patient care, the inclusion of quality assurance, safe practice, and humanistic elements within task descriptions, and the translation of institutional quality assurance policies into new job and task descriptions can provide objective reference points for the evaluation of institutional practice. How to do this is described in Chapter 3 of this volume. The HSMS curriculum objectives can be used in a program of education to change institutional practice. However, the fuel for the motor of a quality assurance and safe practice program is the institution's commitment to its goals at every level. It takes institutional support and reinforcement to have desirable practices carried out in day to day practice.

## A CHECK LIST FOR CONSUMERS

We present below a list of conditions or practices which the consumer of diagnostic radiology services has a right to investigate beforehand, or demand during a procedure. We offer this list to enhance the consumer's awareness and self-image as a powerful decision maker and not a helpless victim of mysterious forces. At the same time, we respect the professionalism of the physician and technologist. We do not question that, when asked to carry out quality services, he or she will do so with intelligence and concern. In the marketplace, mutual respect and a desire to give one's best is enhanced by adequate information and wisely placed trust.

1. The potential patient has a right to be told the purpose of all diagnostic radiography procedures, and all should be defensible by the prescribing physician.

2. The potential patient should insist on having information explaining any proposed invasive procedures such as a contrast study, angiography, or neuroradiology, and should be asked to sign a consent form prior to the administration of any relaxant or sedative.

3. An institution should be willing to discuss its quality assurance program with the potential patient and answer specific questions about its safe practices.

4. The potential patient should inquire whether the institution has a policy of periodically testing and calibrating equipment, whether there is a film processor monitoring program, and has a right to make such an inquiry.

5. The patient should expect to be questioned about allergies if a radiographic examination is to be conducted involving contrast media, and should make sure that any allergies are recorded by offering the information, even if not asked for it.

6. A female patient of child-bearing age should expect to be questioned about possible pregnancy.

7. The patient should feel free to ask questions about any medical concerns and about what will happen during procedures, should be interested in learning how he or she can cooperate, and has a right to expect respectful, caring responses.

8. The patient should expect to receive some form of gonadal shielding for all radiographic examinations or an explanation of why this is not feasible, such as when the area of interest makes this impossible.

9. The patient should expect to see the operator of x-ray equipment use a light system to adjust the area to be exposed (collimation) rather than rely on the size of a cassette.

10. The patient has a right to inquire about the radiation record keeping practices of the institution; as a minimum request the patient has a right to a record showing the date, the type of examination, the equipment used, and the views obtained; if possible, the patient should also receive a record of estimated exposure including exposure due to "reject" radiographs.

11. The patient should be encouraged to inform other physicians of diagnostic radiographs already taken, and has a right to require that other physicians have access to such radiographs.

12. The patient has the right to feel like the center of attention in any procedure involving his or her health.

# CHAPTER 5

## ANALYTIC PROCEDURES AND DETAILS

This chapter offers a detailed account of the analytic procedures used in the HSMS method. The first section provides a general description of the procedures and computer programs.[1] The second and third sections provide a step by step presentation of how we did the analysis in diagnostic radiology.

### OVERVIEW

When all the tasks have been scaled for their skill and knowledge scale value requirements we have a raw data matrix in which the rows are the tasks, the columns are the skill and knowledge variables, and the entries are the scale values.[2]

Our purpose is to go from this basic data matrix to recommendations on job ladders. We are essentially asking, how can we group a large number of tasks that require a large number of skills and knowledge categories at varying scale values into a meaningful smaller number of groupings so that the underlying association of skills and knowledges (variance) will be reflected in the groupings of the tasks? Second, how can we go from such groupings of tasks to recommendations of jobs arranged in ladders?

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1 A more technical description of the HSMS analytic techniques and an independent scholars' review appear in Research Report No. 11, op. cit.

2 In the more traditional uses of scaling data, such as in psychometrics, our "tasks" would be "individuals" or "subjects," and the skills and knowledges would be psychological or demographic variables.

Our answer to the first question is the use of a method of factor analysis called "principal components analysis" in a procedure we call "two-mode" factor analysis. The HSMS answer to the second question is the application of common sense to the results of the two-mode analysis.

It is important to note from the outset that the HSMS use of analytic techniques is descriptive. This is an applied use of statistics; we are not attempting to build predictive models or engage in pure research. Therefore, we select the techniques that serve to organize and simplify our data. Our results are suggestive and we use them as such.

We carry out the following steps in order to proceed to our objective:

1. Select the tasks to enter the analysis.
2. Select the variables that have sufficient frequency to enter into the factor analysis.
3. Use principal component factor analysis to examine the structure of the variables. Select a solution (the number of factors) that best describes the relationship among variables.
4. Use two-mode factor analysis to examine the structure of tasks based on the structure of variables. Assign each task to a factor and arrange in rank order within factors.
5. Rank order tasks by "difficulty" within factors by a count of all the skills and knowledges required for tasks and the scale values at which they are required (including variables not part of the factor analysis). Assign tasks to job levels within each factor.
6. Examine results and make job ladder and lattice recommendations.
7. Prepare the data as inputs for curriculum objectives to provide educational ladders to parallel the job ladders.

Selection of Skill and Knowledge Variables

In the HSMS method we first use a program called EDIT to help us reduce our data to an acceptable raw data matrix for later factor analysis. By eliminating from the analysis skill or knowledge variables that appear with very low frequency across tasks, we help to satisfy the statistical requirement that the number of observations (tasks) be significantly larger than the number of variables. We thereby reduce the number of variables that take on a value of zero for most observations. The program also performs a logarithmic transformation on the data to bring them to a closer approximation of linearity among variables.[3]

In our particular computer programs we use a maximum of 144 variables. This results in good observation/variables proportions for our runs. Appendix B presents all the skill and knowledge variables originally found in the data base for each of the four runs, and indicates which set of 144 variables was retained for each run.[4]

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[3] Eliminating variables with low frequency for factor analysis does not mean the loss of information about such variables. Later in the process when tasks are arranged in order of difficulty for assignment to job levels, and in the design of curricula, all the data enter into the analysis. In this case, variables of low frequency do not provide information for grouping tasks, and their elimination is not a loss.

[4] At the end of Appendix B we present the selection decisions, i.e., the frequency below which variables were deleted. Since a count of 144 variables is not usually obtainable simply by choosing a cut-off figure, we select any additional deletions to best retain the information we consider important. We usually eliminate some subdivision knowledge categories if the broader category under which the subdivision is listed is included at a higher frequency. We eliminated Leadership Skills from all the runs because this scale is the only one among the skill scales that often reflects the organizational characteristics of the institution in which the task is found rather than qualities inherent in the task.

We now have a reduced data matrix whose rows are the tasks selected for a given run and whose columns are the 144 variables selected for that run; the entries are scale values adjusted by EDIT.

Factor Analysis

Classical factor analysis deals with statistical observations and variables. It examines the statistical relationship of every variable with every other variable, and groups these in such a way as to best account for all the variability represented by the values of all the observations (tasks) on all the variables. A "factor solution" groups related variables into a given number of "factors" which account for the variance in a test space in a way analogous to the way one regression line accounts for the correlation in two-dimensional space between two variables. With a large number of variables, the object is to replace the separate relationships of each variable with every other variable with a smaller number of interrelated variable groups (factors). Each factor is essentially a construct that expresses the interrelationships within a particular group. The numerical "loading" of a given variable on a factor describes the extent to which the variations in the variable help determine the factor.

In the HSMS method we use two factor analysis computer programs. The first is used to select the factors (groupings) that best describe the interrelationships among skill and knowledge variables. We call this "simple" factor analysis. The second program is used to describe the interrelationships among tasks so as to reflect the skill and knowledge groupings. We call this "two-mode" factor analysis.

The initial factor analysis program which provides the solution for grouping the variables has the name PCVARIM, an abbreviation for

Principal Components Factor Analysis with Varimax Rotation.[5] The outputs of our "simple" factor analysis are arrays, one for each factor "solution," in which the columns are the factors, the rows are the 144 variables, and the entries are the numerical "loadings" of each variable on each factor. A solution is the number of factors into which the array is divided. The loadings reflect the extent to which a variable's scale value variations contribute to the variance accounted for by the factor in the given solution. There are as many solutions as the number of factors into which one desires to see the variance summarized.

Every variable has a loading on every factor. Variables can load on factors within the range of ± .99. Variables which are positively interrelated on a factor will have the same sign. The + or - has no other intrinsic meaning. A loading of ± .40 or more is of interest.

We chose to examine various factor solutions, such as ten-factors, nine-factors, and so on, down to three factors, to explore the possible groupings of variables. This is done by noting which variables

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[5] The PCVARIM program and the two-mode program use a principal components technique (unities rather than communality estimates in the diagonal), with a correlation matrix (rather than a covariance or cross-products matrix), to arrive at principal axis (PA) factors. They use a varimax rotation of the PA factors to produce an orthogonal (rather than oblique) factor solution.

The principal components technique, unlike other factor analytic techniques which first reduce the total variability in a test space, summarizes the total variability in a test space into a smaller number of orthogonal components. This choice of techniques reflects our desire to summarize the variance, not reduce it, and to create factors that are maximally independent of one another. Since we use correlation matrices, our solutions are not dependent on the standard deviations of the variables (covariance matrices are) or on the means and standard deviations (cross-product matrices are).

have "high loadings" on a given factor in a given solution. The identities of the variables that determine a factor give one some sense of the underlying meaning of the factor. In the case of HSMS, a factor may or may not suggest the skills and knowledge needed for a function, a specialization, a type of service, or a type of procedure.

The choice of an acceptable factor solution (that is, the choice of six or seven factors rather than three or ten factors) can be based on statistical criteria or on common sense, or a combination of these.

For HSMS we first eliminate solutions with so many factors that some factors have only three or fewer variables with relatively high loadings (that is, ± .45 or more). We eliminate solutions with so few factors that no underlying structure of interest is evident. We narrow our choice to those solutions that make sense and on which most variables have a high loading on some factor, but in which few variables have high loadings on several factors. We look for stability of factor structures across several factor solutions. We then choose that solution which makes the most sense; that is, the underlying structure is most easily understood in terms of what we know about the nature of the work. (We discuss the factor solutions we selected later in this chapter.)

The two-mode factor program produces the "task factors." The number of task factors is determined by the solution chosen for the number

of variable factors.[6] The output of the two-mode analysis is an array in which the columns are the factors, and the rows are all the tasks. The factors correspond to their variable factor counterparts. The entries are the loadings of each task on every factor.

The characteristic sign of the variable factor determines the sign of the task factor. Within this, a task's loading can be very high, an integer, can range anywhere down to zero, through zero, and can have still lower values of the opposite sign. (In reporting the results we use the convention of presenting high values as positive. The negative sign is used to represent loadings of less than zero.)

A task's loading on a factor reflects the skills and knowledge categories required for the task, the scale values at which they are required, and the loading of those particular variables on the corresponding variable factor. Thus, it is possible to examine a task's loading on all the factors and assign it to the factor on which it has its highest loading (within sign). The meaning here is that this is the factor with which the task has most in common.

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[6] In the two-mode program the same reduced data matrix is used to form two conceptually different but necessarily related correlation matrices. One is the correlation of every variable with every other variable across all the tasks (as in simple factor analysis); the other is the correlation of every task with every other task across all the variables. The program produces the varimax representation of the principal components of the variable matrix as in the PCVARIM solution described earlier. The program also produces a transfer of the principal components of the task correlation matrix based on the Eckert-Young theorem. That is, the "variable mode" is rotated to simple structure and the "task mode" is "counter-rotated" by obtaining the transformed characteristic vectors of the observation mode induced by the varimax rotation of the variable mode.

Low-level tasks which require few skills or knowledge categories, and require them at low scale values will have low loadings on all factors. Skills and knowledges can have inverse (opposite sign) loadings on some factors, and these also influence a task's loading on factors.[7] The difference in loadings for low-level tasks is so insignificant that a common-sense assignment of task to factor is often preferable to a mechanical statistical rule.

Our first ordering of the tasks assigned to given factors is, by rank order of the tasks' loadings on the factor, including only the tasks assigned to that factor. This arrangement is not the same as ordering the tasks by difficulty, since only the 144 variables used in the factor analysis are represented, and the loadings reflect the variables whose variations explain the factor. On the other hand, since the presence of these variables and their scale values do determine the loadings, this arrangement proves to be a good first approximation of the task hierarchy within factors.[8] We use factor loadings for our first ordering of the results to more readily examine the tasks separately within their factors.

Assigning Tasks To Levels: Point Scores[9]

The HSMS MATRIX program allows us to examine the tasks in each

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[7] The loadings are not unlike factor scores with respect to their usefulness; unlike factor scores, tasks which have few variables above zero and low scale values do not take on spuriously high loadings on task factors.

[8] The first four tables in Appendix E present the tasks in descending order of difficulty and also present the tasks' factor loadings for comparison.

[9] The actual assignment to levels of tasks represented in this report is discussed later in this chapter and presented in Appendix E.

factor separately. It presents the tasks assigned to a factor in an array in which the tasks are arranged from left to right in ascending order of their loading on that factor. The tasks are the columns. The rows are all the skill and knowledge variables, listed from top to bottom, in the order in which they appear in the tasks (which are arranged from left to right) including all the variables; the entries are the original scale values. Figure 9 is a hypothetical presentation of a MATRIX array.

This ordering of the array produces a stepwise pattern because skills and knowledge categories that appear in low-level tasks continue to appear across the array and, as higher-level tasks are added, indented new arrays appear for skills and knowledge categories not required for lower-level tasks.

By reading across a row one can see whether a given skill or knowledge category is required for any of the tasks, and at what scale values. One can assign a score of one point to the lowest scale value required, such as 1.0 or 1.5, and increase the points as other scale values appears, such as 2.0, 4.5, or 7.0.

Within a factor some variables are required at the same scale value for all tasks, and some are required at more than one scale value, depending on the task. We assign points to the tasks based on what we find in the array. For example, if a given variable appears for all but one task in a factor, say at 2.0, each task but that one receives a point. If a given variable appears for some tasks at 2.0, for others at 4.5, and for still others at 7.0, the tasks at 2.0 receive one point,

Figure 9. MODEL OF "MATRIX" ARRAY OF SKILLS AND KNOWLEDGES BY TASK AND JOB LEVEL

| Skills and Knowledge Categories | FACTOR I LADDER | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Level 1 | | | Level 2 | | | Level 3 | | |
| | Task 1 | Task 2 | Task 3 | Task 4 | Task 5 | Task 6 | Task 7 | Task 8 | Task 9 |
| Skill 1 | 1.0 | 1.0 | 2.0 | 2.0 | 2.0 | 4.0 | 4.0 | 9.0 | 9.0 |
| * Skill 2 | 1.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 4.0 | 7.0 | 9.0 |
| Skill 3 | | 2.0 | 2.0 | 4.5 | | 4.5 | 2.0 | 7.0 | 7.0 |
| * Knowledge 1 | | | | 1.5 | 1.5 | 1.5 | 7.0 | 1.5 | 7.0 |
| Knowledge 2 | | | | 3.5 | 3.5 | 2.5 | 5.5 | 2.5 | 9.0 |
| Skill 4 | | | | 5.0 | 5.0 | 5.0 | 5.0 | | 5.0 |
| Knowledge 3 | | | | | | | 5.0 | 6.0 | |
| * Knowledge 4 | | | | | | | 3.5 | 9.0 | 9.0 |
| Knowledge 5 | | | | | | | 8.5 | 8.5 | 8.5 |
| Knowledge 6 | | | | | | | 3.5 | 7.5 | 7.5 |
| Knowledge 7 | | | | | | | 7.0 | 7.0 | 9.0 |
| Knowledge 8 | | | | | | | 7.0 | | 8.5 |

* Asterisk denotes variables that determined the factor.

1. Tasks are listed from left to right in ascending order of loading on "task factor."
2. Skills and knowledge categories are listed from top to bottom in order of appearance in the task array.
3. Tasks are assigned to levels based on increasing numbers of skills and knowledges required and their scale values.
4. Not every skill or knowledge appears in all subsequent, higher-level tasks.
5. Scale values do not necessarily rise from level to level.
6. Scale values may vary within a level.

those at 4.5 receive two points, and those at 7.0 receive three points. When this is done for all the variables and tasks in a factor, we add each task's points and list these at the bottom of the MATRIX array.

If we read these "point scores" for tasks from left to right, they roughly approximate the order of the factor loadings, but some rearrangements are inevitable. This is because variables enter into the point scores that were not among the 144 selected for the factor analysis; and variables with little variance would not have high factor loadings on the variable factors.

We now repeat the MATRIX program for each factor. This time the tasks are arranged from left to right in order of their point scores. The profile is now more distinct.

We mark off on each row the first task at which a scale value changes to a higher value, and continue across the row, marking the first appearance of still higher scale values.

We now examine the array both to note at which position (task) large numbers of skill and knowledge categories are required for the first time, and the tasks in which the scale values first rise. We use these step-like demarcation points to assess when we have a change of job level.

Often there is a dramatic point of change. In cases where the array shows no dramatic breaks we supplement our analysis by examining the names of the tasks and using common sense to determine the difference between levels. Our aim is to assign tasks to levels so that tasks with

similar skills and knowledge requirements at similar scale values are assigned to the same job level. Sometimes we include one or more tasks on several factors to provide benchmarks for the comparison of levels across tasks.

Making Job Ladder Recommendations

In our experience, the factor results do not necessarily guarantee that job ladders can be designed. After tasks have been assigned to factors and levels it is possible to find only one level represented for a given factor. This was the case in our pilot test and in diagnostic radiology for factors containing only physician tasks. The sheer number of variables and the high scale values at which they are needed create separate factors. However, we were pleasantly surprised to find some genuine job ladder possibilities in diagnostic radiology.

We have also found that some factors can appear above the first or second level and be logical higher-level steps for the tasks in other factors. This happens when the higher-level factor combines the skill and knowledge requirements of the two other factors. This is the basis for job lattices. We found this situation in our pilot test and again in diagnostic radiology.

THE FACTOR STRUCTURE OF SKILL AND KNOWLEDGE VARIABLES

The first step in our analytic work was the selection of tasks for the analysis. In addition to the 368 tasks identified in diagnostic radiology, HSMS has data for 273 tasks that were identified in our pilot test at an ambulatory care center. Some of these "overlap" with those in diagnostic radiology, giving us a total of 560 tasks. We decided to study

the way the tasks group when all 560 tasks are studied at one time, as well as the groupings of the 368 diagnostic radiology tasks.

We also were concerned with the possible effects on the results from tasks dealing with professional meetings and teaching, since these tasks tend to be scaled for all or most of the skills and knowledges needed in all the tasks of the occupation or job title involved. We decided to do a separate analysis with all the meeting and teaching tasks omitted. As a result of these concerns, we created four separate data "runs," as follows:[10]

Run 1: 560 tasks in diagnostic radiology and ambulatory care.

Run 2: 499 tasks in diagnostic radiology and ambulatory care (teaching and meeting tasks eliminated).

Run 3: 368 tasks in diagnostic radiology.

Run 4: 324 tasks in diagnostic radiology (teaching and meeting tasks eliminated).

The total number of skill and knowledge variables identified with a given run changed as we eliminated tasks. (See Figure 10, below.) To carry out the factor analysis we eliminated enough low-frequency variables in each run to reach the maximum of 144 variables allowed by our factor programs. There were some differences in the composition of the 144 variables among runs, since the frequency of variables was different for each run. Appendix B presents the names of all the variables identified for all the tasks of each run, and further indicates which ones were retained for the factor analysis of a given run.

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[10] The last page of Appendix A indicates which tasks were in each of the runs.

Figure 10. SUMMARY OF TASKS AND VARIABLES BY RUN

| Computer Run | No. of Tasks | No. of Skill, Knowledge Categories | |
|---|---|---|---|
| | | Identified | In factor Analysis |
| 1 | 560 | 272 | 144 |
| 2 | 499 | 267 | 144 |
| 3 | 368 | 207 | 144 |
| 4 | 324 | 201 | 144 |

Detailed information appears in Appendixes A and B.

The Factor Structure of Variables in Diagnostic Radiology and Ambulatory Care: Runs 1 and 2

We examined the Run 1 and Run 2 variable factors first. While some diagnostic radiology does appear in ambulatory care settings (we had found a separate factor in our pilot test), these two runs bring together two largely separate delivery areas in health services. We were curious to see the association of skills and knowledge categories in this broad context.

The procedure was to examine a series of factor solutions for each run. Each "solution" (number of factors) presents an array of loadings for each variable on each factor in the given solution. For each factor we noted every variable with a loading of ± .45 or higher and treated these variables as "determinants" of the given factor.[11] When we found a solution with three or more variables loading high on each factor, we considered the solution worth examining. We studied the composition of the variables to see the "sense" of the factors in the solution.

[11] The co-variation of variables determines a factor. Variables with high loadings on a factor will tend to increase or decrease in scale value in an interrelated way across tasks. Tasks arranged in job ladders that reflect a skill and knowledge factor will tend to require increasing levels of the variables that determine the factor as one climbs the job ladder.

In our earlier pilot test in ambulatory care we had selected a six-factor solution; in this case we decided to examine all the possible solutions from five factors up to ten factors.

Several factors appeared on each solution with no major change from one solution to another. There was always one large factor that accounted for about 80 variables. The highest-loading variables included the reasoning skills, most knowledge categories under "normal structure and function" by systems of the body, metabolic processes, most pathology categories, categories under surgery, growth and development, radiology, and categories under pharmacology. These categories bring to mind what is needed for the radiologist's tasks and the diagnosis of patients.

We found a second stable factor, accounting for about fifteen variables, associated with the structure, functioning and pathology of the nervous system, the ear, and the eye. Disability evaluation, pharmacology categories associated with the nervous system, and categories under sensation and sense perception (behavioral categories) also loaded on this factor. The variables seem to be those needed for neurology, neuroradiology, and possibly health evaluation and diagnosis.

A third stable factor, usually including about fifteen variables, had a rather diverse set of variables associated with it. We found reproduction, conception, contraception, some pathologies, sanitation, epidemiology, categories under rehabilitation, microbiology, development of behavioral processes, and health services administration and policy all with high loadings. This grouping was confusing until we considered the

breadth of the concerns of the family health team we studied in ambulatory care, and the functions of the nurse practitioner and family health worker. These included screening examinations, counseling, health education, and coordination of services. These duties and functions seem to underlie this factor.

Other factors that appeared in each solution were less stable in composition. They appeared in and out of combination with other variables. One of these factors sometimes included the skills of object manipulation, human interaction, consequences of error to humans, and categories such as shock and trauma, asepsis, and several under first aid and care. In other solutions the factor appeared together with categories under pharmacology. We recognized the factor as one suggesting emergency and/or physical patient care, with medication as a possible component.

Another factor that appeared regularly but with differing numbers of variables covered the structure, function, pathology, pharmacology and birth procedure categories associated with obstetrics and gynecology. It sometimes accounted for five and sometimes twenty variables. There was another factor with similar categories associated with a specialty in the gastrointestinal tract.

One factor which appeared in differing combinations was of special interest. We found a combination of variables that we could sometimes identify with the radiologic technologist. In some solutions the categories were combined with the emergency and physical patient care variables. This factor first appeared in the five-factor solution. It in-

cluded guiding and steering, human interaction, oral use of language, reading, writing, figural, symbolic, financial error, and human error skills, regional and topographic anatomy, the musculoskeletal system, bones and joints, diagnostic radiology, some first aid categories, and algebra. In the six-factor solution (which we first considered as the best solution), this group is somewhat reduced, and interaction with radiation appears on the factor.

When we further examined the six-factor solution we found that the knowledge categories associated with quality assurance and the physicist were not yet accounted for. We anticipated that, as a result, the tasks of the physicist would not factor separately and would not load higher than those of the radiologic technologist on any common factor. With only six factors, we would not have a solution that would make sense.

The nine- and ten-factor solutions both contained some factors with only two or three categories with high loadings, and were thus discarded.

The eight-factor solution had a factor containing only categories under pharmacology. This solution was of interest, however, because it included a factor clearly reflecting quality assurance skill and knowledge requirements, i.e., radiobiology, diagnostic radiography, electric circuit theory, interaction with radiation, electronic devices, algebra, reading use of language, symbolic skills, and financial error consequences.

The seven-factor solution became our choice for the combined diagnostic radiology and ambulatory care Run 1 solution. (The seven factors are presented in Appendix D, Table D.1.) The stable factors described

above are there, as are the obstetrics-gynecology and gastrointestinal factors. Patient and emergency care variables appear as a distinct factor. The seventh factor clearly reflects the subjects associated with quality assurance and radiologic technology. What we did not find was a separate factor to bring together the nursing and anatomy needed for radiologic technology with the technological subjects also needed.

We made a comparison of the results of Run 1 with those of Run 2 (with teaching and meeting tasks eliminated). There was a basic similarity for the two runs. On the whole, the Run 1 solutions seemed to make more "sense" and accounted for more variables. As a result, we chose to utilize the Run 1, seven-factor solution as our first approximation of the factor structure of variables.

The Factor Structure of Variables in Diagnostic Radiology: Runs 3 and 4

Runs 3 and 4 contain only the tasks in diagnostic radiology. The factor structure of the variables of these tasks would be of prime interest if career lines were to be uncovered within this functional area rather than across health services. As matters turned out, the factors in Runs 1 and 2 were surprisingly similar to those of Runs 3 and 4; we can say that the Run 3 and 4 solutions are largely contained in the Run 1 and 2 solutions. Diagnostic radiology evidences few career line possibilities to or from ambulatory care, except in nursing or at the lowest job levels where work with materials, equipment, and/or patients is very similar, regardless of context or location.

We examined all the factor solutions from three factors up to eight factors for Run 3. The factor structures again show stability across solutions. They also show great similarity to the Run 1 solutions. The stable factors include the large first factor described above, which suggests the radiologist's activities, and a second factor dealing with neuroradiology.

When we got to the four-factor solution a radiologic technology factor appeared as the third factor and remained relatively stable for all the other solutions. A fourth factor is patient and emergency care, with a large helping of pharmacology, probably associated with administering medications. The five-factor solution retains the first four factors and adds a gastrointestinal factor.

The six-factor solution drops the gastrointestinal factor, maintains the first four factors, and adds an obstetrics-gynecology factor and the longed-for quality assurance factor. Here is a solution with all the attributes we hoped for. We have each of the specialties represented, few variables unaccounted for, and only a small degree of overlap of high-loading variables across factors. (The seven-factor solution added a factor that made little sense; the eight-factor solution added the gastrointestinal factor.)

When we compared the Run 4 solutions with the Run 3 solutions we again found great similarities; the Run 4 solutions made more sense. Thus, our preferred factor structure excludes the effects of meetings and teaching tasks.

Our final choice for a factor solution within diagnostic radiology is the Run 4, six-factor solution. The factors can be described in terms of the skills and knowledge categories associated with: (I) non-neurologic radiology; (II) neuroradiology; (III) radiologic technology; (IV) patient and emergency care; (V) obstetrics-gynecology; and (VI) quality assurance in diagnostic radiology.

Run 1 and Run 4 Results

In Appendix D, Table D.1, we present the factor loadings for the Run 1, seven-factor solution and the Run 4, six-factor solution. The reader can compare the factors. They have been numbered so that the Run 4 factors that are essentially similar to the Run 1 factors have the same factor numbers. Thus, factors I, II, IV, and V are comparable in both solutions. Factors III and VI of the six-factor, Run 4 solution separate radiologic technology from quality assurance; when combined, they are comparable to Factor VII of the seven-factor, Run 1 solution. The results are summarized in Figure 11, below. (Note that we use $\pm$ .45 to select factor solutions and $\pm$ .40 to present factors.)

Both solutions are comparable in the number of variables assigned to factors and in the percentage of variance accounted for. The Run 4, six-factor solution accounts for somewhat fewer variables and more variance.

The stable Factor I radiologist factor is very similar in the two solutions. The Run 1 factor is preferable because it does not have high inverse loadings. The Run 4 factor has a high-loading inverse variable.

Figure 11. COMPARISION OF VARIABLE FACTOR STRUCTURES BY RUN

| Comparisons by Run | Variables at ±.40 or More | Percentage Variance |
|---|---|---|
| Total Run 1, 7-factor solution | 142 | 71% |
| Total Run 4, 6-factor solution | 140 | 76% |
| Factor I, Run 1 | 91 | 34% |
| Factor I, Run 4 | 92 | 38% |
| Factor II, Run 1 | 20 | 8% |
| Factor II, Run 4 | 24 | 14% |
| Factor IV, Run 1 | 18 | 7% |
| Factor IV, Run 4 | 22 | 7% |
| Factor V, Run 1 | 13 | 6% |
| Factor V, Run 4 | 6 | 4% |
| Factor VII, Run 1 | 12 | 4% |
| Factors III and VI, Run 4 | 34 | 13% |
| Factor III, Run 1 | 18 | 7% |
| Factor VI, Run 1 | 10 | 6% |

See Appendix D, Table D.1.

The Run 4 version of Factor II seems preferable for the neuroradiology factor because of the variance it explains and the completeness of the variables involved for the specialty. This is a result of the inclusion of more relevant categories in the factor analysis for Run 4 than was the case for Run 1.

The Run 4 version of Factor IV, patient and emergency care, includes more pharmacology variables and fewer skills and first aid categories than in Run 1. This reflects the different emphasis in tasks in ambulatory care and diagnostic radiology. We prefer the Run 4 version because its Factor IV is more easily distinguished from radiologic technology and is more suggestive of nursing requirements.

There is no doubt that Factors III and VI of Run 4 better reflect the work in quality assurance and radiologic technology than does Factor VII of Run 1. Each of the two Run 4 factors commands more variables than than does Factor VII, which serves to represent both functions.

Thus, the Run 4, six-factor solution appears to better represent the association of variables in diagnostic radiology, with the exception of Factor I which we took from the Run 1 solution.

A remarkable aspect of the results is the stability of the solutions across the two runs, even though one run covers 560 diverse tasks and the other covers a narrower subset of 324 tasks. This lends credence to the solutions chosen and indicates the robust nature of the analysis. On the other hand, the differences serve to remind us that these solutions are merely gross descriptions of the data, and not scientific laws.

## THE FACTOR STRUCTURE OF TASKS

The meaning of the factors really comes alive when we examine which tasks load on which factor. In order to follow the results, a brief review of what the task factors are is presented, and then the task content of the factors is described.

### Interpreting the Two-Mode Task Factor Data

In the HSMS two-mode factor analysis method the selection of a skill-and-knowledge variable factor solution determines the number of factors and the nature of the factors to which tasks can be assigned. The factor structure of tasks is the assignment of tasks to each factor and the arrangement of the tasks of a factor into a hierarchy.

We examined the task structure of the Run 1, seven-factor solution in order to see the structure of radiologic technology tasks in a broad context, and then proceeded with the analysis of the Run 4, six-factor solution. (We comment only briefly on the ambulatory care tasks, because they were not really the subject of this investigation.)

As described earlier, to obtain task factors with the two-mode method we first decide on the number of factors to extract and rotate. The number is the solution chosen in the prior analysis of the factor structure of skill and knowledge variables. The task factors are then shown in an array in which the tasks are the rows and the factors are the columns. The entries are the tasks' numerical loadings on the factors. Each task has a loading on each factor. To interpret the data one must understand what a task factor represents, the meaning of the loadings, and how a task's loading on a factor arises.

Each task factor is a reflection of a corresponding variable factor in the factor solution previously chosen. For example, in Run 1 we chose a seven-factor solution; we got seven task factors. For Run 4 we chose a six-factor solution; we therefore got six task factors. The skill and knowledge variables that determine a variable factor, such as Factor II, determine how tasks will load on the corresponding factor (Factor II) among the task factors.

The meaning of a task's loadings on task factors is as follows. For any given task, the more skill and knowledge categories it requires of those variables that determine a given variable factor, the higher the task's loading will be on the corresponding task factor. The higher the

task's scale values for those variables, the higher the task's loading on the factor. (The influence of each variable can be estimated by noting the variable's loading on the variable factor.) Since a task will have some numerical loading on all task factors, a given task can load low or negatively on factors that are determined by skill or knowledge categories not required for the task. Tasks with no knowledge categories, few skills, and low scale values will probably load negatively on all factors. Negative loadings are interpreted as less than zero in the usual numerical sense.[12]

We interpret the data first by reading across each row in the array and noting the factor on which a task has its highest loading. We also note on which factors a task may have high secondary loadings (high in absolute value but lower than the task's highest loading).[13]

Task Content of Factors

Once each task is assigned to the factor on which it has its highest loading, the task content of the factors emerges. Figure 12, below, summarizes the Run 1 task factors. It presents the task content separately for the ambulatory care tasks and the diagnostic radiology tasks of a given factor.

12 The actual computer output shows factors with "characteristic signs." These carry over from the variable factor loadings to the corresponding task factors. For this report we convert negative-sign factors to their opposite sign because it is easier to interpret results that uniformly use negative loadings to mean loadings less than zero, and the higher a negative figure the lower the loading.

13 While the HSMS data tasks can load with values above unity, but most loadings fall within ranges of ± .90. See Appendix E for the tasks' actual loadings on factors.

Figure 12. SUMMARY OF CHARACTERISTICS OF RUN 1 TASK FACTORS

| Factor Number and Name | Type of Tasks with Highest Loading on Factor | | Comments |
|---|---|---|---|
| | Ambulatory Care | Diagnostic Radiology | |
| I. Non-neurologic radiology. | None | Non-neurologic radiologist tasks, including most of those also loading on Factors V and VI. | Useful for comparison with Factor I of Run 4. |
| II. Diagnosis, neuroradiology. | Most physician diagnosis tasks. | Neuroradiology radiologist tasks. | Run 4 comparison. |
| III. Ambulatory care examinations; counseling, administration, meetings. | Amalgam of functions of nurse practitioner, family health worker; administration, teaching, meeting and counseling tasks. | Administrative, supervisory tasks. | Use to order administrative tasks in Run 4. |
| IV. Patient and emergency care. | Tasks involving physical treatment and care of patients, emergency care; all levels. | Emergency care, first aid, and patient care tasks; radiologic technology angiography examinations; all levels. | Reflects the fact that Run 1 does not have a separate factor for rad. tech. with nursing content. |
| V. Female care. | Obs-gyn. operations, examinations, care, and counseling; all levels. | Obs-gyn. radiologist tasks; most load on Factor I as well. | Run 4 comparison. |
| VI. Gastrointestinal care. | Miscellaneous tasks that include gastrointestinal content; all levels. | GI radiologist tasks; most load higher on Factor I. | Not useful. |
| VII. Radiologic technology, quality assurance, materials. | Miscellaneous and ECG tasks (very few). | Physicist, x-ray equipment testing, film processing; rad. tech. examinations except angiography; all levels. | Combines rad. tech. and quality assurance; excludes nursing content for rad.tech. |
| Non-Factor B: Laboratory procedures. | Lab. procedures such as preparing and reading slides, spun-down samples, other types of analysis. | Low-level tasks that could be assigned elsewhere such as urine testing to Factor VII. | A separate group not reflected in factor solution. |

For details, see Appendix D, Table D.2 and Appendix E.

Factors I and VII are exclusively diagnostic radiology factors. Factors II, V and VI combine ambulatory care and diagnostic radiology tasks dealing with the nervous system, obstetrics-gynecology and the gastrointestinal tract, respectively. When the ambulatory care tasks are removed from these three factors they refer to radiologist specialty tasks exclusively. Factor I is also a radiologist task factor. Thus, Factor IV, which covers emergency care and physical treatment, and is essentially a nursing factor, is the only factor that truly bridges the two areas of diagnostic radiology and ambulatory care. This is also the area of most task overlap.

In this solution we had our first insight into the dual nature of the radiologic technologist's function. The radiologic technologist examinations that most heavily draw on nursing knowledge, such as in angiography, load on Factor IV; this is because Factor VII accounts for the technological aspects of the field. So the tasks of equipment testing and quality assurance load with the other radiologic technologist examination tasks on Factor VII, and the radiologic technologist tasks are split.

A number of tasks made no sense on any factor, but seemed somewhat interrelated. It seems that, with a different set of tasks, they might be part of a new factor. For Run 1 these were laboratory procedures such as preparing and examining slides. We created a separate non-factor group, group B, to differentiate it from non-factor A in the Run 4 results.

Figure 13, below, summarizes the task content of the Run 4 task factors. This structure proved to be the most informative and useful for our needs. Factor III is an exclusively radiologic technology factor. All

Figure 13. SUMMARY OF CHARACTERISTICS OF RUN 4 TASK FACTORS

| Factor Number and Name | Type of Tasks Loading on Factor | Comments |
|---|---|---|
| I. Non-neurologic radiology. | Radiologist tasks in all specialties except neuroradiology. Overlaps with Factor V. | Only radiologist tasks; compare with Run 1. |
| II. Neuroradiology. | Radiologist tasks in neuroradiology. | Only radiologist tasks. |
| III. Radiologic technology. | All patient examination tasks done by radiologic technologists. | Only radiologic technologist tasks. |
| IV. Patient and emergency care. | Emergency care, medications, first aid; tasks dealing with patients' care; all levels. | All tasks dealing with patients and with ambiguous loadings were assigned here. |
| V. Obstetrics-gynecology radiology. | Radiologist tasks in obstetrics-gynecology. Tasks also load on Factor I. | Only radiologist tasks. |
| VI. Quality assurance, materials. | Quality assurance program planning (tasks done by physicist), x-ray equipment and film processor testing; surveys; caring for equipment; all levels. | All tasks dealing with materials, equipment, records, housekeeping, and with ambiguous loadings were assigned here. |
| Non-Factor A. Administration. | Administrative and supervisory tasks. | A separate group not in factor solution; reflects Factor III of Run 1. |

For details, see Appendix D, Table D.2 and Appendix E.

the radiologic examinations load solely on this factor. Factor VI is the factor for quality assurance and the activities associated with the physicist in diagnostic radiology. The patient and emergency care factor (IV) is quite clearly nursing oriented.

As mentioned earlier, there is a problem with low-level tasks which require so few skills or knowledges, and at such low levels, that they have ambiguous loadings. They have low loadings on all the factors, and there is no significant difference among the loadings from one factor to another. The Run 4 factor structure provided a simple, reasonable answer. Only two of the factors show a wide range in the levels of the tasks loading sensibly on them. (The three radiology factors and the radiologic technology factor are not accompanied by lower-level tasks.) However, Factors IV and VI both have tasks of varying levels loading on them. Factor IV deals with people, and Factor VI deals with equipment, materials and records, i.e., things. This classic breakdown is useful for our purposes. Where low-level tasks had ambiguous loadings we assigned each to one or the other factor depending on whether patients were involved in the task or not. With patients, the assignment went to Factor IV; without patients, to Factor VI.

The remaining tasks are administrative tasks. They were assigned to a non-factor grouping based on their loading on Factor III in the Run 1 solution. We call this non-factor A: administration.

The Run 1 task factor structure proved useful for ordering the tasks of Factor I, for assessing the relative position of the teaching and meeting tasks eliminated from Run 4, and for ordering the supervisory and administrative tasks of Run 4 that we grouped as non-factor A.[14]

[14] Of the 324 tasks of Run 4, 18 were assigned to more than one factor. Most of these are the radiologist tasks in obstetrics-gynecology. Only one task appears on more than one factor in the group covered by Factors III, IV and VI. The assignment of all tasks to factors is presented by task and factor number in Appendix B, Table B.2.

gories than others at level 2. However, we did not feel that three tasks warrant their being grouped at a separate technologist job level.[16]

The administrative tasks of non-factor A were assigned to levels based on point score ordering and the way in which these tasks relate to other tasks. These groups are likely never to become separate jobs. They would be attached to jobs created from comparable levels in Factors III, IV, and/or VI. The non-factor A tasks were assigned to two levels: technologist (3) and supervisor (4).

The tables in Appendix E present the tasks of the quality assurance (VI), radiologic technology (III), and patient and emergency care (IV) factors, and non-factor A (administration) in descending order of the tasks' point scores.[17] The tables also present the tasks' loadings on their Run 1 and Run 4 factors, and their assignments to job levels.

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16. All the other level 2 tasks could be learned in a program of much narrower scope than that leading to the registered nurse license. We suggest, therefore, that, should these tasks be able to be assigned to a patient care technician, the additional training for these three tasks could be provided. Special permission to function in these tasks could be obtained in states where injections require the RN license. In Figure 1, presented in Chapter 2, we show these tasks as overlapping level 3, but assigned to a level 2 job.

17 The radiologist factors (I, II and V) require so many categories that deriving point scores becomes a massive undertaking. It is not needed, because all the tasks on each factor are obviously at the same level. The tasks in these factors are listed in Appendix E in descending order of their factor loadings.

## APPENDIXES

APPENDIX A

TASKS USED IN FACTOR ANALYSIS
BY CODE AND ABBREVIATED NAME

| TASK CODE | ABBREVIATED TASK NAME | SOURCE[a] |
|---|---|---|
| 1 | Conducting a radiographic barium enema study of lower gastrointestinal tract of any non-pediatric patient. | 1* |
| 2 | Conducting a radiographic barium swallow study of esophagus of any non-pediatric patient. | 1 |
| 3 | Conducting a radiographic barium study of upper gastrointestinal tract of any non-pediatric patient. | 1* |
| 4 | Conducting pelvic pneumography and/or pangynecography of non-infant female patient. | 1* |
| 5 | Conducting hysterography or hysterosalpingography of a non-pediatric female patient. | 1 |
| 6 | Reading, interpreting and making recommendations on routine radiographic materials; dictating findings and recommendations. | 1* |
| 7 | Observing and evaluating work of radiologic technologists or students in diagnostic radiography, and deciding whether training is needed. | 2* |
| 8 | Shutting down computerized transverse axial scanning equipment. | 3 |
| 9 | Diagnosing medical condition and deciding care for non-child patient. | * |

[a] Numbers 1, 2 or 3 refer to the volume numbers of Research Report No. 7, Task Descriptions in Diagnostic Radiology, in which the task descriptions appear. Asterisk (*) indicates that task was used in an earlier pilot test of the Health Services Mobility Study method at an ambulatory care center. Task with asterisk and number were used in pilot test and also were found in diagnostic radiology.

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 10 | Deciding whether to proceed with care and administer medication to non-child patient. | * |
| 11 | Performing routine pelvic exam on adult female patient. | * |
| 12 | Removing a wart from non-child patient. | * |
| 13 | Setting up and teaching IV apparatus for non-child patient. | * |
| 14 | Evaluating a skin specimen slide for fungi. | * |
| 15 | Determining presence of trichomonas on slide. | * |
| 16 | Examining a slide for gonococci. | * |
| 17 | Determining if suspect EKG reading is true or artifact. | * |
| 18 | Drawing blood from any non-pediatric patient's vein on orders. | 3* |
| 19 | Administering test for allergy to iodine based contrast medium of any patient. | 3* |
| 20 | Directing respiratory tract tomography. | 1 |
| 21 | Informally instructing interns, residents in patient care. | * |
| 22 | Responding to cardiac arrest call; providing care. | * |
| 23 | Filling in forms and letters describing patient's medical condition for institutions. | * |
| 24 | Assessing urgency of follow-up for no-show patients. | * |
| 25 | Participating in Team conference as internist. | * |
| 26 | Participating in committees at institution. | * |
| 27 | Giving lectures to staff and students on health and medical subjects. | * |
| 28 | Providing emergency life support care. | * |
| 29 | Informally instructing subordinates in patient care. | * |
| 30 | Making spinal tap of adult patient. | * |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 31 | Taking bone marrow specimen from adult patient. | * |
| 32 | Suturing lacerations. | * |
| 33 | Removing any patient's sutures. | 3* |
| 34 | Incising and draining abscess or boil. | * |
| 35 | Examining spun-down urine sediment and supernate. | * |
| 36 | Examining blood slide. | * |
| 37 | Providing treatment of injuries. | * |
| 38 | Removing foreign object from eye and/or ear. | * |
| 39 | Diagnosing obs-gyn condition and deciding care for female patient. | * |
| 40 | Deciding whether to administer or change medication for female patient. | * |
| 41 | Cauterizing, performing cervical biopsy, removing polyps, inserting IUD, correcting retroflexed uterus, providing vaginal care for female patient. | * |
| 42 | Providing fertility assistance for female patient. | * |
| 43 | Delivering baby through the vagina. | * |
| 44 | Conducting Cesarean section delivery. | * |
| 45 | Conducting curettage abortion. | * |
| 46 | Conducting saline abortion. | * |
| 47 | Conducting surgical excision of uterus, ovaries; hysterectomy through abdomen or vagina. | * |
| 48 | Conducting vaginal plastic surgery or correction of vaginal hernia. | * |
| 49 | Conducting ligation of fallopian tubes. | * |
| 50 | Taking sample of amniotic fluid from pregnant patient. | * |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 51 | Determining presence of monilia fungi on slide. | * |
| 52 | Contributing to Team conference as obstetrician-gynecologist. | * |
| 53 | Instructing nurses in obs-gyn patient care. | * |
| 54 | Participating in obs-gyn physician conference. | * |
| 55 | Diagnosing health and development and deciding care for pediatric patient. | * |
| 56 | Deciding whether to go ahead with pediatric care and administer medication. | * |
| 57 | Removing foreign object from patient's ear. | * |
| 58 | Preparing patient with foreign body in eye by applying dye strip. | * |
| 59 | Removing large blunt object from pharynx. | * |
| 60 | Conducting spinal tap of pediatric patient. | * |
| 61 | Drawing blood from pediatric patient's vein. | * |
| 62 | Taking bone marrow sample from pediatric patient. | * |
| 63 | Giving lectures, tests for Nurse Practitioners; considering delegation of duties. | * |
| 64 | Informally training Nurse Practioners; considering delegation of duties. | * |
| 65 | Preparing specimens such as extravascular body fluids, washings, cell and/or tissue biopsies for transportation to laboratory. | 3 |
| 66 | Formulating a problem for clinical research in diagnostic radiology. | 1 |
| 67 | Conducting literature review for clinical research problem in diagnostic radiology. | 1 |
| 68 | Preparing research design in clinical diagnostic radiology; supervising research; analyzing, evaluating results; and preparing report. | 1 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 69 | Processing exposed x-ray film in automatic processor. | 3* |
| 70 | Inspecting, cleaning and readying x-ray film hand processing equipment for use. | 3* |
| 71 | Processing exposed x-ray film manually. | 3* |
| 72 | Loading x-ray film cassette(s), nonscreen film holder(s), box-(es), and/or roll film cartridges. | 3* |
| 73 | Reassuring any patient and/or accompanying adult about x-ray and/or fluoroscopy procedures. | 3* |
| 74 | Explaining to any out-patient or accompanying adult proper at-home procedures to follow prior to coming for radiographic or fluoroscopic examination. | 3* |
| 75 | Translating a Spanish-English conversation. | * |
| 76 | Checking supplies and ordering non-drug materials needed by department. | 3* |
| 77 | Providing emergency care for any patient having adverse reaction to radiographic contrast medium, procedures, or accident. | 3 |
| 78 | Checking and jacketing patient's radiographs, ultrasonograms, and/or C.T.T. scans with requisition sheets and prior diagnostic materials and placing for filing or interpreting. | 3* |
| 79 | Preparing barium sulfate contrast medium as ordered or for standard use. | 3* |
| 80 | Preparing materials or trays with medications and materials for special treatments or procedures according to standard orders. | 3* |
| 81 | Providing technical quality review of "plain film" radiographs. | 2* |
| 82 | Providing clinical training for radiologic technologists or students in radiographic technology. | 2 |
| 83 | Identifying obvious medical condition of adult and following up on care. | * |
| 84 | Performing pelvic exam on adult female including specimens and follow-up. | * |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 85 | Conducting post partum examination and evaluating condition. | * |
| 86 | Conducting prenatal examination of pregnant patient; reporting abnormalities. | * |
| 87 | Evaluating or following routine, prescribed treatment or care. | * |
| 88 | Identifying a juvenile's health condition. | * |
| 89 | Assessing condition of neonate and following up. | * |
| 90 | Providing post-hospital visit to chronic schizophrenic patient. | * |
| 91 | Administering first aid in emergency. | * |
| 92 | Removing thread stitches if appropriate. | * |
| 93 | Applying prepackaged tine test for TB. | * |
| 94 | Assessing tine test reaction after time lapse; following up on results. | * |
| 95 | Testing a urine sample by tablet or dipstick method and recording. | 3* |
| 96 | Taking a throat culture specimen and labeling. | * |
| 97 | Teaching parent how or collecting specimen from child for pinworm test. | * |
| 98 | Obtaining a clean catch urine specimen from any patient and preparing for laboratory. | 3* |
| 99 | Administering and scoring a Snellen vision screening test of any non-infant patient and referring for further tests. | * |
| 100 | Giving Denver Development test to child. | * |
| 101 | Counseling in sex, contraception, VD, abortion. | * |
| 102 | Reinforcing or explaining to patient chronic or special care procedures for daily living. | * |
| 103 | Measuring, fitting diaphragm for female patient. | * |
| 104 | Administering common range of motion exercises on orders, to any patient. | * |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 105 | Irrigating, dressing, bandaging wound or burn as appropriate. | * |
| 106 | Teaching patient postural drainage technique. | * |
| 107 | Teaching patient self examination and care of breasts. | * |
| 108 | Teaching patient reagent or dipstick urine test. | * |
| 109 | Teaching any patient irrigation, change, care of colostomy. | * |
| 110 | Answering any patient's questions on care at RN level. | * |
| 111 | Providing safety inspection of patient's home. | * |
| 112 | Teaching a diabetic patient to take medication or insulin injection. | * |
| 113 | Giving any patient general reassurance. | 3* |
| 114 | Giving pragmatic counseling to patient on personal problems. | * |
| 115 | Deciding on and arranging referral of patient to agency. | * |
| 116 | Deciding on and/or arranging for transportation for outpatient to and/or from treatment or examination. | * |
| 117 | Irrigating and changing indwelling catheter. | * |
| 118 | Teaching patient irrigation of indwelling catheter. | * |
| 119 | Teaching parent how to prepare infant's formula, how to feed, bathe, diaper infant. | * |
| 120 | Preparing, presenting classes for Family Health Workers; evaluating students. | * |
| 121 | Participating in Family Health Team conference as Nurse Practitioner. | * |
| 122 | Coordinating multi-agency examinations for patient. | * |
| 123 | Instructing Family Health Workers or Nurse-interns in patient care. | * |
| 124 | Arranging to cover temporary or permanent staff shortages. | * |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 125 | Participating in RN committee work on health care procedures. | * |
| 126 | Approving or changing requisition forms of subordinates. | * |
| 127 | Planning and approving subordinates' patient visit work schedules. | * |
| 128 | Checking supply of narcotics or regulated drugs (or witnessing count); reordering, picking up, and restocking. | 3* |
| 129 | Checking supply and ordering non-narcotic medicinals needed by department. | 3* |
| 130 | Obtaining pharmaceuticals as ordered and storing. | * |
| 131 | Making assignments of staff to work areas, procedures, and/or MD's and/or vacations and lunch hours. | 3* |
| 132 | Requesting repair, replacement or other services of another hospital department orally and/or filling out requisition. | 3* |
| 133 | Administering subcutaneous or intramuscular injection for any patient according to MD's orders after having quantity checked. | 3* |
| 134 | Logging and/or tallying patient services and/or instructional case record materials for use in record keeping, billing or instruction. | 3* |
| 135 | Cleaning an examination or treatment room after use. | 3* |
| 136 | Checking and storing order for non-narcotic drugs and/or supplies. | 3* |
| 137 | Delivering prepared specimens or cultures to lab or incubator. | 3* |
| 138 | Reporting observed symptoms and concerns of any patient to physician or staff member. | 3* |
| 139 | Assessing results of tine test. | * |
| 140 | Teaching patient how to do urine test using tablet. | * |
| 141 | Testing stool specimen for blood using tablet. | * |
| 142 | Administering rectal medication as ordered. | * |
| 143 | Catheterizing any female urethra as ordered. | 3* |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 144 | Preparing hot water sterilizer for use. | * |
| 145 | Preparing treatment or examination equipment for sterilization in autoclave. | 3* |
| 146 | Setting autoclave. | * |
| 147 | Preparing or changing technique charts for specific x-ray and fluoroscopic equipment on orders. | 3 |
| 148 | Answering patients' phone questions at LPN capability. | * |
| 149 | Sterilizing equipment in hot water sterilizer. | * |
| 150 | Checking medications for expiration dates. | * |
| 151 | Preparing treatment or examination room(s) for use. | * |
| 152 | Administering prepacked smallpox vaccine to any patient on orders. | * |
| 153 | Assisting physician or co-worker in special examination or treatment procedures. | 3* |
| 154 | Participating in Unit conference as LPN. | * |
| 155 | Obtaining urine specimen on orders. | 3* |
| 156 | Irrigating, cleaning, dressing or redressing any patient's wound, burn, or opening for catheter as ordered. | 3* |
| 157 | Checking chart for entry of lab results. | * |
| 158 | Informally observing and evaluating patient care work of nursing and technologist staff in diagnostic radiography, and deciding whether training is needed. | 3 |
| 159 | Checking reason for non-appearance of out-patient for examination or treatment and arranging for rescheduling. | * |
| 160 | Escorting patient within institution. | * |
| 161 | Weighing and measuring patient and recording. | * |
| 162 | Irrigating patient's ear with solution as ordered. | * |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 163 | Filling out institutional report form (such as for cancellation) as ordered by MD. | 3 |
| 164 | Filling out patient identification information on labels and forms in anticipation of need or as requested. | 3* |
| 165 | Keeping attendance records and recording or reporting excessive lateness and/or absenteeism. | 3* |
| 166 | Using isolation and decontamination techniques to prepare examination or treatment room or area and clean up afterwards for patient with infectious or communicable condition. | 3 |
| 167 | Inspecting and cleaning intensifying screens in cassette holders. | 3 |
| 168 | Taking throat cultures from incubator for assessment by physician. | * |
| 169 | Collecting physician's assessments of throat cultures. | * |
| 170 | Assisting patient in dressing. | * |
| 171 | Assessing urgency of need for physician to see emergency patient. | * |
| 172 | Taking stool specimen from patient and testing for blood. | * |
| 173 | Checking accuracy of x-ray machine timers (except phototimers) with spinning top test. | 3 |
| 174 | Washing and placing equipment in sterilizer. | * |
| 175 | Performing penetrometer calibration test of kVp or mA selectors of x-ray machine output. | 3 |
| 176 | Removing sterilized equipment from autoclave and storing. | * |
| 177 | Treating patient for ringworm on orders. | * |
| 178 | Checking, preparing fluoroscope controls (and phototimer). | 3 |
| 179 | Preparing bottle for intravenous infusion. | * |
| 180 | Preparing blood samples for the laboratory. | 3* |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 181 | Catheterizing any male or female patient's urethra with retention balloon catheter. | 3* |
| 182 | Setting up and using suction machine to clear airway or to assist with gastric lavage. | 3* |
| 183 | Inducing vomiting in patient with medication on orders. | * |
| 184 | Relocking equipment box(es) with breakaway lock. | 3 |
| 185 | Administering oxygen from portable or piped outlet unit using oronasal or nasal mask according to MD's orders. | 3* |
| 186 | Orienting new staff member(s) to departmental standard operating and administrative procedures, floor plan, location of equipment and supplies, record keeping. | 3* |
| 187 | Checking cassettes for proper film-screen contact. | 3 |
| 188 | Applying cold towels, compress, or ice bath to patient to reduce fever, on orders. | * |
| 189 | Treating patient for lice by shampooing, on orders. | * |
| 190 | Assisting patient to or from wheelchair, stretcher, bed, or table and/or transporting patient to designated area. | 3* |
| 191 | Applying splint on orders. | * |
| 192 | Inspecting, checking, preparing xeroradiography equipment for use. | 3 |
| 193 | Having any patient and materials prepared for special procedure and readying patient for examination. | 3* |
| 194 | Administering eye or ear drops to any patient on orders. | * |
| 195 | Applying an eye patch for any patient on orders. | * |
| 196 | Giving patient enema kit and instructions for use. | * |
| 197 | Reinforcing prescribed diet and medication. | * |
| 198 | Administering medication orally to any patient according to MD's orders after having quantity checked. | 3* |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 199 | Taking and recording vital signs (temperature, pulse, respiration and blood pressure) of any patient. | 3* |
| 200 | Applying hot compress to patient on orders. | * |
| 201 | Giving cold water or alcohol rub on orders. | * |
| 202 | Giving introductory information on birth control devices on orders. | * |
| 203 | Reinforcing any patient's diet and suggesting ethnic substitutes. | * |
| 204 | Providing orientation tour of facilities and procedures at Center to visitors. | * |
| 205 | Giving a patient an enema on doctor's orders. | * |
| 206 | Examining, treating bedridden patient for bed sores. | * |
| 207 | Testing plaster in home for lead and reporting positive finding. | * |
| 208 | Collecting stool specimen from patient and taking to lab. | * |
| 209 | Giving alcohol bath to patient for fever; reporting if no effect. | * |
| 210 | Bathing any adult bedridden patient. | * |
| 211 | Teaching parent how to bathe and diaper an infant. | * |
| 212 | Assisting any non-infant patient to bathe or shower. | * |
| 213 | Treating a baby for cradle cap. | * |
| 214 | Shampooing a patient with itchy scalp. | * |
| 215 | Teaching a parent how to prepare an infant's formula. | * |
| 216 | Teaching bottle feeding and burping to new mother. | * |
| 217 | Preparing food; feeding non-infant patient. | * |
| 218 | Bandaging or changing bandage of patient's minor wound as ordered. | * |
| 219 | Accompanying patient to any social agency. | * |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 220 | Calling person to phone or writing message. | * |
| 221 | Making oral presentation on good health practices to community people. | * |
| 222 | Making photocopies of documents, collating, and stapling. | 3* |
| 223 | Making up unoccupied bed or stretcher bed. | 3* |
| 224 | Deciding whether to make and making an occupied bed. | * |
| 225 | Checking patient's medicines and having old ones discarded. | * |
| 226 | Giving basic sex education, contraception and abortion information to patient. | * |
| 227 | Checking for presence and condition of emergency supplies in proper locations; and restocking as needed. | 3 |
| 228 | Teaching TB patient and family proper health practices. | * |
| 229 | Changing patient's colostomy bag and irrigating on orders. | * |
| 230 | Preparing materials for use in a catheter irrigation. | * |
| 231 | Delivering and/or picking up forms and supplies. | * |
| 232 | Helping any patient needing assistance in walking. | * |
| 233 | Teaching patient how to irrigate eye with water. | * |
| 234 | Delivering medicine to any patient and explaining how to take as ordered. | * |
| 235 | Judging what supplies are needed and requesting. | * |
| 236 | Discussing personal, social, health problems with patient. | * |
| 237 | Discussing consumer protection and helping patient with budgeting. | * |
| 238 | Deciding whether patient needs homemaking services and doing if so decided. | * |
| 239 | Participating in Family Health Team conference as Family Health Worker. | * |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 240 | Deciding and arranging appointment for patient at Center. | * |
| 241 | Providing job orientation to new co-worker Family Health Worker. | * |
| 242 | Discussing job description accuracy. | * |
| 243 | Restraining any patient. | 3 |
| 244 | Teaching patient or parent temperature taking and care of thermometer. | * |
| 245 | Orienting and taking intake information from new family at Center. | * |
| 246 | Reviewing intake information on family; assessing priority of problems. | * |
| 247 | Deciding whether family that moved should stay with Family Health Team originally assigned. | * |
| 248 | Conducting routine prenatal examination. | * |
| 249 | Conducting routine post partum examination. | * |
| 250 | Conducting routine neonate examination. | * |
| 251 | Conducting routine examination of any patient over six months. | * |
| 252 | Conducting routine examination of chronic disease patient. | * |
| 253 | Following up on patient discharged from hospital. | * |
| 254 | Planning a weekly work schedule for approval. | * |
| 255 | Contributing opinion at Unit conference as Medical Assistant. | * |
| 256 | Administering prepacked polio vaccine on orders. | * |
| 257 | Administering and scoring Keystone or Snellen vision screening test of any non-infant patient. | * |
| 258 | Reinforcing patient in use of contraceptive. | * |
| 259 | Taking partial history from patient. | * |
| 260 | Preparing a hypodermic needle with injection dosage on orders. | 3* |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 261 | Answering telephone in Unit and taking message. | * |
| 262 | Taking an electrocardiogram of any patient as ordered or determined. | 3* |
| 263 | Cutting and mounting an EKG strip on a self-adhesive EKG chart. | * |
| 264 | Ordering duplicate copies of forms, records, or documents. | 3* |
| 265 | Filing or obtaining records from files by patient identification number and/or name. | * |
| 266 | Placing and arranging non-drug supplies. | * |
| 267 | Processing exposed Polaroid x-ray film with Polaroid automatic processing equipment. | 3* |
| 268 | Replacing cardiograph paper in EKG machine(s). | * |
| 269 | Loading empty cassette with Polaroid x-ray film. | 3** |
| 270 | Demonstrating and explaining to visitors or staff how EKG is taken. | * |
| 271 | Deciding whether to call staff person to evaluate whether unusual EKG reading is artifact, or calling physician in case of serious patient distress. | 3* |
| 272 | Preparing and adjusting schedules for patient procedures. | 3 |
| 273 | Cleaning, inspecting and readying automatic x-ray film processor(s) for use. | 3* |
| 274 | Adding predetermined instruments and supplies to prepared procedure trays. | 3 |
| 275 | Preparing radiographic subtraction prints. | 3 |
| 276 | Making minor adjustments or repair on automatic x-ray film processor. | 3 |
| 277 | Assigning scheduled patients to procedure rooms in appropriate order. | 3 |
| 278 | Checking on reasons for nonappearance of in-patients for examinations or treatment. | 3 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 279 | Notifying ward or floor personnel to ready and transport in-patients who are scheduled for specific procedures at specific times. | 3 |
| 280 | Participating in monitoring of personal exposure to radiation by periodically turning in and replacing film strip in badge worn by performer. | 3 |
| 281 | Checking in-patients' identity against patients' treatment and medication check lists; stamping arrival and departure times; attaching cards to patients indicating special conditions. | 3 |
| 282 | Escorting adult out-patients to and/or from dressing rooms, treatment rooms and/or waiting areas. | 3 |
| 283 | On orders, deciding whether wound of any patient needing change of dressing needs attention of RN; changing simple dry dressing or reinforcing wet dressing. | 3 |
| 284 | Checking presence and functioning of oxygen and/or suction equipment, and amounts of oxygen. | 3 |
| 285 | Checking for presence of emergency supplies in proper locations. | 3 |
| 286 | Filling out standard order for linen; picking up, folding and storing. | 3 |
| 287 | On orders, placing order for specific dietetic meal; picking up, delivering, and feeding patient if so decided. | 3 |
| 288 | Filling out and delivering standard order for food items for department; picking up, and placing food for storage. | 3 |
| 289 | Bottle feeding a baby with pre-prepared formula. | 3 |
| 290 | Changing any patient's colostomy bag on orders. | 3 |
| 291 | Taking and reporting temperature of any non-pediatric patient with oral thermometer on orders. | 3 |
| 292 | Obtaining and examining fresh stool from any patient and reporting unusual or suspicious appearance, on orders. | 3 |
| 293 | Attending personal meeting with supervisor on functioning or personal, work-related problems. | 3 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 294 | Assigning subordinate and explaining assignment to transport patient, obtain materials or documents, or assist co-worker. | 3 |
| 295 | Participating in meeting of nursing personnel in x-ray department. | 3 |
| 296 | Providing first aid in x-ray department emergency. | 3 |
| 297 | Obtaining and checking keypunch control card for serial cassette changer as ordered. | 3 |
| 298 | Administering medication orally to any patient according to MD's orders. | 3 |
| 299 | Administering subcutaneous or intramuscular injection for any patient according to MD's orders. | 3 |
| 300 | Checking and submitting accumulated patient's treatment and medication check lists for in and out time stamps. | 3 |
| 301 | Diapering a baby. | 3 |
| 302 | Placing or making call and delivering non-medical message at patient or co-worker's request. | 3 |
| 303 | Arranging, measuring and recording food intake and excretory output as ordered. | 3 |
| 304 | Readying emergency cart. | 3 |
| 305 | Providing informal clinical training in patient care for non-MD personnel in diagnostic radiography. | 3 |
| 306 | Formally evaluating subordinates' work by filling out descriptive and/or rating-scale evaluation forms. | 3 |
| 307 | Conducting a private personnel meeting with subordinate. | 3 |
| 308 | Setting up and monitoring any patient's electrocardiogram during special procedure. | 3 |
| 309 | Calling and participating as supervisor in meeting of subordinates in department. | 3 |
| 310 | Selecting gastrointestinal and biliary tract radiographic materials for use in case conference or lecture presentations or for inclusion in library. | 1 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 311 | Deciding on type of urographic procedure(s) to order for any patient in consultation with referring physician and/or specialists. | 1 |
| 312 | Conducting intravenous pyelography (IVP) examination of any non-pediatric patient. | |
| 313 | Directing nephrotomography of any patient. | 1 |
| 314 | Deciding whether to order non-neurologic computerized transverse axial tomography for any patient and/or alternative studies in consultation with referring physician. | 1 |
| 315 | Performing renal cyst puncture and conducting related radiography of any patient. | 1 |
| 316 | Assisting in renal biopsy of any patient by using fluoroscopy to place biopsy needle. | 1 |
| 317 | Reading, interpreting and making recommendations on urographic materials; or giving opinions to co-workers; explaining opinions or dictating findings and recommendations. | 1 |
| 318 | Providing clinical training for radiology residents in urographic procedures. | 1 |
| 319 | Applying print coater to photographs. | 3 |
| 320 | Planning and presenting lectures on assigned aspects of radiology for medical students. | 1 |
| 321 | Participating in radiologists meeting to arrive at overall clinical and academic assessments of residents in radiology. | 1 |
| 322 | Deciding on diagnostic radiology library acquisitions of books, journals and radiographic materials; coding library acquisitions. | 1 |
| 323 | Participating in meetings of radiologists, urologists and nephrologists to discuss new developments, cases of interest, and case problems in the fields of urology and urography. | 1 |
| 324 | Participating in meetings of physicians involved with arthritis to discuss new developments, cases of interest and case problems in the field. | 1 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 325 | Participating in meetings of radiologists, surgeons and pathologists to discuss new developments, cases of interest and case problems in the fields of surgery and radiology. | 1 |
| 326 | Participating in diagnostic radiology departmental meeting. | 1 |
| 327 | Participating in monitoring of personal exposure to radiation by periodically turning in and replacing film strip in badge; evaluating posted exposure listings. | 3 |
| 328 | Deciding whether to order lymphangiography of any patient or alternative studies and recommending technique, in consultation with referring physician. | 1 |
| 329 | Conducting lymphangiography of any patient. | 1 |
| 330 | Reading, interpreting and making recommendations on lymphangiograms, or giving opinions to co-workers, explaining opinions or dictating findings and recommendations. | 1 |
| 331 | Deciding whether to order non-neurologic tomography for any patient or alternative studies, and recommending technique in consultation with referring physician. | 1 |
| 332 | Reading, interpreting and making recommendations on non-neurological tomograms or giving opinions to co-workers; explaining opinions or dictating findings and recommendations. | 1 |
| 333 | Deciding on and scheduling cleft palate radiological study for any patient. | 1 |
| 334 | Conducting a fluoroscopic and cineradiographic cleft palate study of any patient. | 1 |
| 335 | Reading, interpreting and making recommendations on cineradiographic cleft palate studies; explaining opinions, making presentation, or dictating findings and recommendations. | 1 |
| 336 | Providing clinical training for radiology residents in lymphangiography procedures. | 1 |
| 337 | Participating in meetings with pulmonary specialists, surgeons and pathologists to discuss new developments, cases of interest, and case problems in pulmonary medicine, surgical pathology and thoracic surgery. | 1 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 338 | Participating in meetings of physicians involved with plastic surgery to discuss new developments, cases of interest, and case problems in the field. | 1 |
| 339 | Deciding on type of gastrointestinal and/or biliary radiographic examinations to order for any patient in consultation with referring physician and/or specialists. | 1 |
| 340 | Conducting hypotonic duodenography of any non-pediatric patient. | 1 |
| 341 | Conducting small bowel enema radiographic study of any non-pediatric patient. | 1 |
| 342 | Evaluating oral cholecystograms or oral cholangiograms; conducting fluoroscopy and/or post-fatty meal, post-evacuation study of any non-infant patient involved if so decided. | 1 |
| 343 | Conducting percutaneous (transhepatic) cholangiography of any non-pediatric patient. | 1 |
| 344 | Conducting intravenous cholangiography and cholecystography (IVC) of any non-infant patient. | 1 |
| 345 | Conducting T-tube cholangiography of any patient. | 1 |
| 346 | Reading, interpreting and making recommendations on radiographs of gastrointestinal and/or biliary tracts, or giving opinions to co-workers; explaining opinions or dictating findings and recommendations. | 1 |
| 347 | Providing clinical training for radiology residents in radiographic study of the gastrointestinal and biliary tracts. | 1 |
| 348 | Planning and presenting lectures or case conferences on gastrointestinal and biliary tract radiology for radiology residents. | 1 |
| 349 | Planning and presenting lectures on gastrointestinal and biliary tract radiology for medical students. | 1 |
| 350 | Conducting counseling on professional or personal problems with residents in radiology. | 1 |
| 351 | Deciding on whether to enter suggested radiographs of gastrointestinal and biliary tracts into log book based on quality and educational value. | 1 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 352 | Participating in meetings of radiologists, surgeons and pathologists to discuss new developments, cases of interest and case problems in the field of gastrointestinal and biliary surgery and radiology. | 1 |
| 353 | Participating in meeting of diagnostic x-ray department technologists. | 2 |
| 354 | Obtaining patient records for use in examination, procedure, treatment or conference. | 3 |
| 355 | Taking plain film radiographs of fingers, hand(s) or wrists of non-infant patient. | 2 |
| 356 | Taking plain film radiographs of forearm and/or elbow joint of non-infant patient. | 2 |
| 357 | Taking plain film radiographs of humerus and/or shoulder girdle of non-infant patient. | 2 |
| 358 | Taking plain film radiographs of toes, foot and/or ankle joint of non-pediatric patient. | 2 |
| 359 | Taking plain film radiographs of leg(s), knee(s) and/or femur(s), of non-infant patient. | 2 |
| 360 | Taking plain film radiographs of pelvis, hips and/or upper femora of non-infant patient. | 2 |
| 361 | Taking plain film radiographs of vertebral column of non-infant patient. | 2 |
| 362 | Taking plain film radiographs of sternum, ribs and/or thoracic viscera of non-infant patient. | 2 |
| 363 | Taking plain film radiographs of abdominal contents of non-infant patient. | 2 |
| 364 | Taking radiographs of anterior portion of the neck of non-infant patient. | 2 |
| 365 | Taking plain film radiographs of the skull and/or face of non-infant patient. | 2 |
| 366 | Taking plain film radiographs of the paranasal sinuses of a non-infant patient. | 2 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 367 | Taking preliminary localization radiographs of foreign bodies in orbit or eye of non-infant patient. | 2 |
| 368 | Taking mammograms (radiography or xeroradiography) of non-infant patient. | 2 |
| 369 | Preparing, transporting, setting up and returning mobile portable radiography equipment for bedside radiography. | 2 |
| 370 | Taking operative orthopedic radiographs of any patient (such as in hip pinning). | 2 |
| 371 | Taking operative cholangiograms, pancreatograms or similar operative radiographs of any patient. | 2 |
| 372 | Taking intravisceral or isolated operating room radiographs of any patient. | 2 |
| 373 | Taking operating room radiographs for opaque foreign body search. | 2 |
| 374 | Taking tomograms of non-infant patient. | 2 |
| 375 | Taking sialograms of any patient. | 2 |
| 376 | Taking lymphangiograms or lymphadenograms of any patient. | 2 |
| 377 | Taking positive contrast arthrograms (especially of knee) of any patient. | 2 |
| 378 | Taking bronchograms of a non-pediatric patient. | 2 |
| 379 | Carrying out radiologic technology for bronchoscopy or needle lung biopsy of a non-pediatric patient. | 2 |
| 380 | Providing technical assistance for laryngography or cleft palate study of any patient (or any similar fluoroscopic examination including spot filming and/or cineradiography). | 2 |
| 381 | Taking upper GI radiographs of non-pediatric patient. | 2 |
| 382 | Taking small intestine intubation radiographs of a non-pediatric patient. | 2 |
| 383 | Taking barium enema radiographs of non-pediatric patient. | 2 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 384 | Taking oral cholecystograms and cholangiograms of non-infant patient. | 2 |
| 385 | Taking intravenous cholangiograms and cholecystograms of non-infant patient. | 2 |
| 386 | Taking percutaneous or T-tube cholangiograms of non-infant patient. | 2 |
| 387 | Taking intravenous pyelograms and urograms of non-pediatric patient. | 2 |
| 388 | Taking infusion nephrotomograms of any patient. | 2 |
| 389 | Taking percutaneous antegrade or renal cyst pyelograms of non-infant patient. | 2 |
| 390 | Taking cystograms and voiding cystourethrograms of any patient. | 2 |
| 391 | Selecting and assembling radiographs and related case history information for use in case conference in diagnostic radiology. | 1 |
| 392 | Planning and presenting cases and/or related lectures on diagnostic radiology and pathology to pathologists, radiologists and residents. | 1 |
| 393 | Reviewing and selecting current and/or inactive radiographs for instructional use. | 1 |
| 394 | Comparing prior radiographic diagnoses with later pathology and/or autopsy reports and reporting discrepancies to appropriate radiologists. | 1 |
| 395 | Conducting a radiographic air contrast study of stomach of any non-pediatric patient. | 1 |
| 396 | Deciding on type of neuroradiologic procedure(s) to order for any patient in consultation with referring physician and/or neurologist. | 1 |
| 397 | Conducting cerebral angiography of any patient. | 1 |
| 398 | Conducting pneumoencephalography of any patient. | 1 |
| 399 | Cooperating with surgeon in conducting brain ventriculography of any patient. | 1 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 400 | Conducting positive contrast myelography of any patient. | 1 |
| 401 | Conducting air contrast myelography of any patient. | 1 |
| 402 | Conducting mammographic examination of any patient's breasts. | 1 |
| 403 | Reading, interpreting and making recommendations on mammographic materials, or giving opinions to co-workers; explaining opinions or dictating findings and recommendations. | 1 |
| 404 | Reading, interpreting and making recommendations on neuroradiographic materials, and/or giving opinions to clinicians or co-workers; explaining opinions or dictating findings and recommendations. | 1 |
| 405 | Providing clinical training for radiology residents in neuroradiology procedures. | 1 |
| 406 | Providing clinical training for radiology residents in mammography procedures. | 1 |
| 407 | Planning and presenting lectures or case conferences on neuroradiology for radiology residents. | 1 |
| 408 | Participating in meetings of radiologists, surgeons and neurologists to discuss new developments, cases of interest and case problems in the fields of neurology, surgery and neuroradiology. | 1 |
| 409 | Deciding on type of respiratory radiographic examination(s) to order for any patient in consultation with referring physician and/or specialists. | 1 |
| 410 | Conducting bronchoscopy and related biopsy and secretion sampling of any non-pediatric patient. | 1 |
| 411 | Conducting bronchography of any non-pediatric patient. | 1 |
| 412 | Conducting laryngography of any non-pediatric patient. | 1 |
| 413 | Conducting aspiration or tissue needle biopsy of the lung of any non-pediatric patient. | 1 |
| 414 | Reading, interpreting and making recommendations on radiographic materials involving bronchi, lungs, trachea and/or larynx, or giving opinions to co-workers; explaining opinions or dictating findings and recommendations. | 1 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 415 | Planning and presenting lectures or case conferences on pulmonary, tracheal, bronchial and laryngeal radiology for radiology residents. | 1 |
| 416 | Providing clinical training for radiology residents in radiographic procedures of lungs, bronchi, trachea and/or larynx. | 1 |
| 417 | Planning and presenting lectures on pulmonary, bronchial, tracheal and laryngeal radiography for medical students. | 1 |
| 418 | Deciding on type of obstetrical radiographic procedures to order for pregnant patient in consultation with referring obstetrician. | 1 |
| 419 | Calculating and interpreting radiographic pelvimetry using Colcher-Sussman technique. | 1 |
| 420 | Conducting intrauterine fetal radiography for intrauterine transfusion in consultation with obstetrician. | 1 |
| 421 | Deciding on type of gynecological radiographic procedures to order for non-pediatric female patient in consultation with referring physician. | 1 |
| 422 | Reading, interpreting and making recommendations on obstetrical and/or gynecological radiographic studies and related material or giving opinions to clinicians or co-workers; explaining opinions or dictating findings and recommendations. | 1 |
| 423 | Participating in meetings of radiologists, obstetricians, and gynecologists to discuss new developments, cases of interest and case problems of mutual interest. | 1 |
| 424 | Providing clinical training for radiology residents in obstetrical and gynecological radiographic procedures. | 1 |
| 425 | Planning and presenting lectures or case conferences on obstetrical and gynecological radiology for radiology residents. | 1 |
| 426 | Conducting percutaneous antegrade pyelography of any non-pediatric patient. | 1 |
| 427 | Conducting retrograde venography of the internal jugular veins, posterior fossa dural sinus system and/or orbit of any patient. | 1 |
| 428 | Conducting orbital and/or cavernous sinus venography of any patient by frontal vein route. | 1 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 429 | Conducting selective spinal cord angiography of any patient. | 1 |
| 430 | Conducting positive contrast posterior fossa myelography of any patient. | 1 |
| 431 | Conducting discography of any patient. | 1 |
| 432 | Directing skull tomography of any patient. | 1 |
| 433 | Conducting sialography of any patient. | 1 |
| 434 | Reading, interpreting and making recommendations on sialography and related materials or giving opinions to co-workers; explaining opinions or dictating findings and recommendations. | 1 |
| 435 | Providing clinical training for radiology residents in ear, nose and throat radiography and sialography. | 1 |
| 436 | Conducting positive contrast arthrography (especially of knee) of any patient. | 1 |
| 437 | Reading, interpreting and making recommendations on orthopedic radiographs and/or arthrograms and related studies of bones and joints or giving opinions to clinicians or co-workers; explaining opinions or dictating findings and recommendations. | 1 |
| 438 | Providing clinical training for radiology residents in orthopedic radiology and arthrography. | 1 |
| 439 | Ordering or approving changes in technical factor selector settings to compensate for a change in quality of x-ray machine output. | 3 |
| 440 | Directing computerized transverse axial tomography of the skull and brain of any patient. | 1 |
| 441 | Deciding on type of pediatric radiographic examination(s) to order for pediatric patient in consultation with referring physician and/or pediatric specialist. | 1 |
| 442 | Conducting choanal radiography of pediatric patient. | 1 |
| 443 | Conducting bronchography of pediatric patient in consultation with pediatrician(s) and anesthesiologist. | 1 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 444 | Conducting intravenous excretory urography (IVP) and inferior vena cavography of pediatric patient. | 1 |
| 445 | Conducting retrograde voiding cystourethrography of pediatric patient. | 1 |
| 446 | Conducting radiography of external fistula or sinus tract of any patient. | 1 |
| 447 | Conducting vaginography of pediatric patient for intersex condition. | 1 |
| 448 | Conducting percutaneous peritoneography/inguinal herniography of pediatric patient. | 1 |
| 449 | Reading and interpreting radiographs for bone-age study. | 1 |
| 450 | Evaluating plain films of pediatric gastrointestinal tract to localize obstructions and/or foreign bodies. | 1 |
| 451 | Removing foreign object from pediatric upper esophagus under fluoroscopic control. | 1 |
| 452 | Conducting esophageal radiography of pediatric patient. | 1 |
| 453 | Conducting radiographic barium study of upper gastrointestinal tract of pediatric patient. | 1 |
| 454 | Conducting a radiographic barium enema study of lower gastrointestinal tract of pediatric patient. | 1 |
| 455 | Conducting defecography of pediatric patient. | 1 |
| 456 | Conducting diagnosis and hydrostatic reduction of intussusception of pediatric patient. | 1 |
| 457 | Conducting fluoroscopic inspiration-expiration examination of pediatric patient. | 1 |
| 458 | Reading, interpreting and making recommendations on radiographic and related studies of pediatric patients or giving opinions to clinicians or co-workers; explaining opinions or dictating findings and recommendations. | 1 |
| 459 | Participating in meetings of radiologists, surgeons and pediatricians to discuss new developments, cases of interest, and case problems in the field of pediatric surgery and radiology. | 1 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 460 | Providing clinical training for radiology residents in pediatric radiography. | 1 |
| 461 | Planning and presenting lectures or case conferences on pediatric radiology for radiology residents. | 1 |
| 462 | Planning and presenting lectures on pediatric radiology for medical students. | 1 |
| 463 | Taking retrograde pyelograms and ureterograms of non-pediatric patients. | 2 |
| 464 | Providing technical assistance for an examination of any patient requiring fluoroscopic control and spot filming. | 2 |
| 465 | Taking pelvic pneumograms and/or hysterosalpingograms of non-pediatric female patient. | 2 |
| 466 | Taking radiographs of a pregnant patient's abdomen for fetography, amniography, placentography. | 2 |
| 467 | Taking radiographs of a pregnant patient's uterus for intrauterine transfusion. | 2 |
| 468 | Taking radiographs of a pregnant patient's pelvis for Colcher-Sussman pelvimetry. | 2 |
| 469 | Deciding on type of non-neurologic angiography procedure to order for any patient in consultation with referring physician, surgeon, and/or other specialist. | 1 |
| 470 | Conducting peripheral arteriography of any patient by percutaneous selective catheterization or direct needle puncture. | 1 |
| 471 | Conducting ascending or descending venography of lower extremities of any patient by direct needle puncture. | 1 |
| 472 | Conducting catheter thoracic aortography of any patient. | 1 |
| 473 | Conducting catheter abdominal aortography and/or selective visceral arteriography of any patient. | 1 |
| 474 | Conducting percutaneous translumbar abdominal aortography of any patient. | 1 |
| 475 | Conducting percutaneous splenoportography of any patient. | 1 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 476 | Conducting selective pelvic arteriography of non-pediatric gravid or nongravid female patient. | 1 |
| 477 | Conducting catheter pulmonary angiography of any patient. | 1 |
| 478 | Conducting selective bronchial arteriography of any patient. | 1 |
| 479 | Conducting selective thyroid angiography of any patient. | 1 |
| 480 | Conducting selective subclavian arteriography of any non-pediatric patient to evaluate thoracic outlet syndrome. | 1 |
| 481 | Conducting intravenous angiocardiography of any patient by percutaneous selective catheterization or direct needle puncture. | 1 |
| 482 | Conducting catheter vena cavography and/or selective renal or adrenal venography of any non-infant patient. | 1 |
| 483 | Conducting percutaneous coronary arteriography and/or left ventriculography of any patient. | 1 |
| 484 | Reading, interpreting and making recommendations on non-neurologic angiographic and related studies and/or giving opinions to clinicians or co-workers; explaining opinions or dictating findings and recommendations. | 1 |
| 485 | Participating in meetings of angiographers, vascular surgeons and cardiologists to discuss new developments, cases of interest, and case problems in the field of angiography, vascular and cardiovascular surgery. | 1 |
| 486 | Providing clinical training for radiology resident in non-neurologic angiography. | 1 |
| 487 | Planning and presenting lectures or case conferences on non-neurologic angiography for radiology residents. | 1 |
| 488 | Directing computerized transverse axial tomography of the body of any patient. | 1 |
| 489 | Reading, interpreting and making recommendations on non-neurological computerized transverse axial tomographic scans of the body, and/or giving opinions to clinicians or co-workers; explaining opinions or dictating findings and recommendations. | 1 |
| 490 | Mummying or wrapping an infant or young pediatric patient. | 3 |
| 491 | Taking plain film radiographs of the skull of infant patient. | 2 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 492 | Taking plain film radiographs of vertebral column of infant patient. | 2 |
| 493 | Taking plain film radiographs of the upper extremities of infant patient. | 2 |
| 494 | Taking radiographs of neck, chest of infant patient. | 2 |
| 495 | Taking plain film radiographs of abdomen of infant patient. | 2 |
| 496 | Taking plain film radiographs of the lower extremities of infant or pediatric patient. | 2 |
| 497 | Taking radiographs for choanal atresia study of infant patient. | 2 |
| 498 | Taking bronchograms of a pediatric patient. | 2 |
| 499 | Taking upper GI radiographs of pediatric patient. | 2 |
| 500 | Taking barium enema, intussusception or defecography radiographs of pediatric patient. | 2 |
| 501 | Taking percutaneous peritoneograms/herniograms of pediatric patient. | 2 |
| 502 | Taking excretory intravenous inferior vena cavograms and urograms of pediatric patient. | 2 |
| 503 | Taking genitograms or fistulograms of any patient for intersex, external fistula or sinus tract examination. | 2 |
| 504 | Taking cerebral angiograms or venograms of any patient. | 2 |
| 505 | Taking pneumoencephalograms or brain ventriculograms of any patient. | 2 |
| 506 | Taking positive contrast spinal or posterior fossa myelograms of any patient. | 2 |
| 507 | Taking diskograms of any patient. | 2 |
| 508 | Taking air or gas contrast myelograms of any patient. | 2 |
| 509 | Taking spinal cord angiograms of any patient. | 2 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 510 | Taking peripheral angiograms of any patient (after percutaneous needle or catheter entry, translumbar puncture, ascending or descending venous entry). | 2 |
| 511 | Taking catheter thoracic and/or abdominal aortograms of any patient, and/or selective visceral arteriograms (bronchial or abdominal). | 2 |
| 512 | Taking selective pelvic angiograms of non-pediatric gravid or nongravid female patient. | 2 |
| 513 | Taking intravenous angiocardiograms of any patient. | 2 |
| 514 | Taking selective thyroid angiograms of any patient. | 2 |
| 515 | Taking catheter inferior vena cavograms and/or renal or adrenal venograms of non-infant patient. | 2 |
| 516 | Taking percutaneous splenoportograms of any patient. | 2 |
| 517 | Taking selective subclavian arteriograms of non-pediatric patient for thoracic outlet syndrome evaluation. | 2 |
| 518 | Taking selective pulmonary angiograms or selective angiocardiograms of any patient. | 2 |
| 519 | Taking percutaneous coronary arteriograms and/or left ventriculograms of any patient. | 2 |
| 520 | Preparing any patient and attaching electrodes for electrocardiogram monitoring. | 3 |
| 521 | Applying digital or manual pressure to any patient's arterial or venous puncture site as ordered. | 3 |
| 522 | Applying pressure dressing to arterial or venous puncture site. | 3 |
| 523 | Preparing computerized transverse axial tomography (C.T.T.) equipment for use. | 3 |
| 524 | Providing preventive maintenance for display tube surface, camera, disc and/or tape drive units, and/or scanning assembly (especially water-using head box assembly) of computerized transverse axial tomography (C.T.T.) equipment. | 3 |
| 525 | Checking calibration and accuracy of C.T.T. equipment by making test scans. | 3 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 526 | Taking computerized transverse axial tomographic (C.T.T.) scans of any patient. | 2 |
| 527 | Retrieving, displaying and making photographs, printouts and/or magnetic tape records of computerized transverse axial tomographic (C.T.T.) scans. | 3 |
| 528 | Designing, maintaining, evaluating calibration and/or dose monitoring program in diagnostic radiology. | 3 |
| 529 | Checking x-ray field limitation, x-ray receptor and light field alignment, minimum TOD, TFD and field size indicators for diagnostic x-ray equipment. | 3 |
| 530 | Checking fluoroscopic and spot film x-ray field limitation, x-ray field and image receptor alignment, maximum TID, minimum TOD, and other requirements. | 3 |
| 531 | Testing whether diagnostic x-ray tube overload protection and/or effective focal spot size meet acceptable standards. | 3 |
| 532 | Checking and/or performing direct calibration tests of diagnostic radiography equipment exposure timers. | 3 |
| 533 | Checking automatic exposure termination of diagnostic radiography equipment. | 3 |
| 534 | Providing visual and radiographic or fluoroscopic inspection of personnel shielding devices such as leaded gloves, aprons, sheets, gonadal shields. | 3 |
| 535 | Performing calibration tests of kVp, mA, mAs, exposure rates, reproducibility on diagnostic radiography equipment using direct measuring instruments and/or radiographic comparisons. | 3 |
| 536 | Providing visual and/or manual inspection of diagnostic radiography system. | 3 |
| 537 | Checking diagnostic tomography x-ray equipment for mechanical operation, fulcrum position, resolution, exposure uniformity and/or grid alignment. | 3 |
| 538 | Estimating HVL and checking adequacy of filtration of diagnostic x-ray equipment. | 3 |
| 539 | Checking bucky grid alignment and/or centering in diagnostic radiography equipment. | 1 |

| TASK CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 540 | Checking fluoroscopic automatic brightness control system and/or focus, resolution and distortion of the optical system. | 3 |
| 541 | Evaluating accepted and rejected radiographs to identify any technical problems with staff functioning, equipment, radiation protection. | 3 |
| 542 | Designing, maintaining, evaluating darkroom and/or film processor monitoring program in diagnostic radiology. | 3 |
| 543 | Monitoring and evaluating x-ray film processors. | 3 |
| 544 | Determining exposure characteristics of x-ray and/or dosimetric films. | 3 |
| 545 | Monitoring patient exposure rates for routine diagnostic x-ray procedures. | 3 |
| 546 | Designing, maintaining, evaluating radiation protection and monitoring programs in diagnostic radiology. | 3 |
| 547 | Determining primary and secondary structural shielding required for diagnostic x-ray installations. | 3 |
| 548 | Checking maximum entrance exposure rate and primary barrier transmitted radiation rate for fluoroscopic equipment. | 3 |
| 549 | Checking the leakage radiation rate from the source assembly of diagnostic x-ray equipment. | 3 |
| 550 | Conducting protection survey of stray radiation within diagnostic x-ray installation and transmission across primary and secondary protective barriers. | 3 |
| 551 | Preparing personnel radiation monitoring dosimetric film or TLD badges and distributing. | 3 |
| 552 | Collecting and/or distributing personnel monitoring dosimetric badge inserts and preparing for outside or in-house processing and reading. | 3 |
| 553 | Reading and recording exposure from personnel monitoring film or thermoluminescent dosimeters. | 3 |
| 554 | Entering, evaluating occupational radiation exposure data and initiating action on dangerous levels. | 3 |

| TASK-CODE | ABBREVIATED TASK NAME | SOURCE |
|---|---|---|
| 555 | Investigating reasons for reported high occupational radiation exposure and initiating remediation. | 3 |
| 556 | Calibrating diagnostic x-ray test, survey, or measuring instruments. | 3 |
| 557 | Collecting and presenting technical information about and/or recommending new diagnostic x-ray equipment. | 3 |
| 558 | Providing clinical training for staff in a diagnostic radiology department in quality assurance tests of equipment, in radiation protection procedures, and related maintenance. | 3 |
| 559 | Planning and presenting lectures and/or related laboratory sessions on radiation and/or health physics for students in professional programs for diagnostic radiology, in medical school, or in medical sciences. | 3 |
| 560 | Preparing lectures or participating in meetings of staff members in diagnostic radiology on radiation protection and quality assurance requirements and practices. | 3 |

Note: Factor analyses for the work in diagnostic radiology were based on the following task runs:

Run 1: All 560 tasks covering ambulatory care and diagnostic radiology.

Run 2: With teaching, conference and professional meeting tasks removed, covering ambulatory care and diagnostic radiology. Total of 499 tasks. Exclusions: Tasks 7,21,25,26,27,29,52,53,54,63, 64,82,120,121,123,125,154,158,239,255,295,305, 309,318,320,321,323,324,325,326,336,337,338,347, 348,349,352,353,392,405,406,407,408,415,416,417, 423,424,425,435,438,459,460,461,462,485,486,497, 558,559,560.

Run 3: Same as Run 1 with exclusively ambulatory care tasks removed, covering only diagnostic radiology. Total of 368 tasks. Excluded tasks are those in Appendix A marked only by asterisks.

Run 4: Same as Run 3 covering only diagnostic radiology, with teaching, conference and professional meeting tasks removed as for Run 2. Total of 324 tasks.

APPENDIX B. SKILLS AND KNOWLEDGES IDENTIFIED IN AMBULATORY CARE AND DIAGNOSTIC RADIOLOGY[a]

| Skill or Knowledge Category Number and Name | Run 1 | | Run 2 | | Run 3 | | Run 4 | |
|---|---|---|---|---|---|---|---|---|
| | L | FA | L | FA | L | FA | L | FA |
| Locomotion Skills | X | | X | | | | | |
| Object Manipulation Skills | X | X | X | X | X | X | X | X |
| Guiding or Steering Skills | X | X | X | X | X | X | X | X |
| Human Interaction Skills | X | X | X | X | X | X | X | X |
| Leadership Skills | X | | X | | X | | X | |
| Oral Use of a Relevant Language | X | X | X | X | X | X | X | X |
| Reading Use of a Relevant Language | X | X | X | X | X | X | X | X |
| Written Use of a Relevant Language | X | X | X | X | X | X | X | X |
| Decision Making on Methods | X | X | X | X | X | X | X | X |
| Decision Making on Quality | X | X | X | X | X | X | X | X |
| Figural Skills | X | X | X | X | X | X | X | X |
| Symbolic Skills | X | X | X | X | X | X | X | X |
| Taxonomic Skills | X | X | X | X | X | X | X | X |
| Implicative Skills | X | X | X | X | X | X | X | X |
| Financial Consequences of Error | X | X | X | X | X | X | X | X |
| Consequences of Error To Humans | X | X | X | X | X | X | X | X |
| 11200000 Genetics | X | | X | | X | | X | |
| 11720000 Vertebrate zoology (through mammalia, but excluding humans) | X | | X | | X | | X | |
| 11731000 Normal structure and function (human anatomy and physiology) | X | X | X | X | X | X | X | X |
| 11731100 Regional anatomy (includes head and neck, thorax and abdomen, pelvis and perineum, lower and upper limbs, and skeleton) | X | X | X | X | X | X | X | X |
| 11731200 Topographic anatomy (relation of external manifestations to internal structure and function) | X | X | X | X | X | X | X | X |
| 11731300 Hematopoietic system (includes blood, red and white blood cells, platelets, and bone marrow, liver, and spleen in their blood forming function) | X | X | X | X | X | X | X | X |
| 11731400 Circulatory system (cardiovascular system; includes heart, veins, arteries, lymphatics) | X | X | X | X | X | X | X | X |
| 11731500 Respiratory system | X | X | X | X | X | X | X | X |
| 11731600 Digestive system | X | X | X | X | X | X | X | X |
| 11731610 Mouth, pharynx (digestive function), esophagus (includes tongue, teeth, and salivary glands) | X | X | X | X | X | X | X | X |

[a] Refers to the 460 tasks listed in Appendix A. Tasks included in each run are indicated at the end of Appendix A. The letter X indicates whether the skill or knowledge category was listed in the run (L), and/or was among the 144 variables used in the factor analysis (FA) for the run.

APPENDIX B (continued)

| Knowledge Category Number and Name | | Run 1 | | Run 2 | | Run 3 | | Run 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | L | FA | L | FA | L | FA | L | FA |
| 11731620 | Stomach and small intestine (includes duodenum, jejunum, ileum) | X | X | X | X | X | X | X | X |
| 11731630 | Large intestine (colon) and rectum (includes appendix, anus, and mesentery) | X | X | X | X | X | X | X | X |
| 11731640 | Liver, biliary system, and pancreas (includes gallbladder, cystic duct, bile duct, pancreatic duct, ampulla of Vater) | X | X | X | X | X | X | X | X |
| 11731700 | Urinary system (includes kidney, ureter, bladder, urethra, external genitalia) | X | X | X | X | X | X | X | X |
| 11731800 | Musculoskeletal system | X | X | X | X | X | X | X | X |
| 11731810 | Muscles | X | X | X | X | X | X | X | X |
| 11731820 | Bones and joints (includes ligaments and tendons) | X | X | X | X | X | X | X | X |
| 11731831 | Skin and sweat glands | X | | X | | X | X | X | X |
| 11731832 | Hair | X | | X | | | | | |
| 11731833 | Nails | X | | X | | | | | |
| 11731900 | Nervous system | X | X | X | X | X | X | X | X |
| 11731910 | Central nervous system (brain and spinal cord) | X | X | X | X | X | X | X | X |
| 11731920 | Peripheral nervous system | X | X | X | X | X | X | X | X |
| 11731930 | Autonomic nervous system (includes sympathetic and parasympathetic nerves) | X | X | X | X | X | X | X | X |
| 11731941 | Olfactory nerve and receptors | X | | X | | X | | X | |
| 11731942 | Taste buds | X | | X | | X | | X | |
| 11731943 | Eye and optic nerve | X | X | X | X | X | X | X | X |
| 11731944 | Touch, heat, cold and pain receptors | X | | X | | X | X | X | X |
| 11731945 | The ear (excludes balance function) | X | X | X | X | X | X | X | X |
| 11731946 | Kinesthetic receptors (includes semicircular canals) | X | | X | | X | X | X | X |
| 11732100 | Immunologic system (includes immunological mechanisms, humoral and cellular factors) | X | X | X | X | X | X | X | X |
| 11732210 | Endocrine glands and their hormone physiology (includes pituitary, adrenal, thyroid, parathyroid, pineal, and pancreas, ovary and testes in their endocrine functions) | X | X | X | X | X | X | X | X |
| 11732220 | Reproduction | X | X | X | X | X | X | X | X |
| 11732221 | Conception and contraception | X | X | X | X | X | X | X | X |

APPENDIX B (continued)

| Knowledge Category Number and Name | | Run 1 | | Run 2 | | Run 3 | | Run 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | L | FA | L | FA | L | FA | L | FA |
| 11732222 | Male reproductive system | X | X | X | X | X | X | X | X |
| 11732223 | Female reproductive system (includes the body changes associated with ovulation, conception and pregnancy, e.g., development of placenta) | X | X | X | X | X | X | X | X |
| 11732300 | Homeostasis of fluids (includes fluid and electrolyte balance) | X | X | X | X | X | X | X | X |
| 11732400 | Metabolism | X | X | X | X | X | X | X | X |
| 11733000 | Pathology (human abnormal function and structure; includes the etiologic and diagnostic aspects of disease) | X | X | X | X | X | X | X | X |
| 11733100 | Infective and parasitic diseases | X | X | X | X | X | X | X | X |
| 11733200 | Neoplasms (cancerous growths) | X | X | X | X | X | X | X | X |
| 11733300 | Endocrine, nutritional, and metabolic disorders | X | X | X | X | X | X | X | X |
| 11733400 | Disorders of blood and blood-forming organs | X | X | X | X | X | X | X | X |
| 11733510 | Disorders of the central nervous system | X | X | X | X | X | X | X | X |
| 11733520 | Disorders of the peripheral nervous system | X | X | X | X | X | X | X | X |
| 11733530 | Disorders of the autonomic nervous system | X | X | X | X | X | X | X | X |
| 11733541 | Disorders of the olfactory nerve and receptors | X | | X | | X | | X | |
| 11733542 | Disorders of the taste buds | X | | X | | X | | X | |
| 11733543 | Disorders of the eye and optic nerve | X | X | X | X | X | X | X | X |
| 11733544 | Disorders of touch, heat, cold and pain receptors | X | | X | | X | X | X | X |
| 11733545 | Disorders of the ear | X | X | X | X | X | X | X | X |
| 11733546 | Disorders of kinesthetic receptors | X | | X | | X | X | X | X |
| 11733600 | Disorders of the circulatory system | X | X | X | X | X | X | X | X |
| 11733700 | Disorders of the digestive system | X | X | X | X | X | X | X | X |
| 11733800 | Disorders of the respiratory system | X | X | X | X | X | X | X | X |
| 11733900 | Disorders of the uro-genital system | X | X | X | X | X | X | X | X |
| 11734100 | Disorders of the skin and subcutaneous tissues | X | X | X | X | X | X | X | X |
| 11734200 | Disorders of the musculoskeletal system and connective tissues | X | X | X | X | X | X | X | X |

APPENDIX B (continued)

| Knowledge Category Number and Name | | Run 1 | | Run 2 | | Run 3 | | Run 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | L | FA | L | FA | L | FA | L | FA |
| 11734300 | Congenital abnormalities | X | X | X | X | X | X | X | X |
| 11734400 | Disorders and complications of pregnancy, childbirth and the puerperium | X | X | X | X | X | X | X | X |
| 11734500 | Perinatal morbidity and mortality (shortly before or after birth) | X | X | X | X | X | X | X | X |
| 11734600 | Burns | X | X | X | X | X | X | X | X |
| 11734700 | Poisoning | X | X | X | X | X | X | X | X |
| 11734800 | Shock and trauma | X | X | X | X | X | X | X | X |
| 11735000 | Surgery | X | X | X | X | X | X | X | X |
| 11735100 | Operative procedures (also includes biopsy, removal of tumors, removal of organs, Caesarian section, removal of drains) | X | X | X | X | X | X | X | X |
| 11735200 | Amputation and disarticulation | X | | X | | X | X | X | X |
| 11735300 | Repair surgery (includes plastic surgery, pedicle revision, surgical graft, anastomosis, fistulization, open reduction, fixation, fusion, stabilization) | X | X | X | X | X | X | X | X |
| 11735400 | Introductory procedures (includes injections, transfusion, irrigation, catheterization, intubation, tracheotomy) | X | X | X | X | X | X | X | X |
| 11735500 | Endoscopy (direct visual observation of bronchi, esophagus, duodenum, colon, etc. with an endoscope) | X | X | X | X | X | X | X | X |
| 11735600 | Suture (also includes ligature, suture materials) | X | X | X | X | X | X | X | X |
| 11735700 | Manipulation (includes application of plaster, splint or traction, dilation or stretching) | X | X | X | X | X | X | X | X |
| 11735800 | Delivery methods for childbirth (includes the circumstances governing the delivery method chosen such as abnormal presentation of baby (transverse section, breech), medical history of mother) | X | X | X | X | X | X | X | X |
| 11736000 | Anesthesiology (includes open anesthetics, semiopen, insufflation, absorption, intravenous, infiltration, field and nerve block methods) | X | X | X | X | X | X | X | X |

APPENDIX B (continued)

| Knowledge Category Number and Name | Run 1 | | Run 2 | | Run 3 | | Run 4 | |
|---|---|---|---|---|---|---|---|---|
| | L | FA | L | FA | L | FA | L | FA |
| 11737000 First aid and care | X | X | X | X | X | X | X | X |
| 11737100 Bandages, dressings, tourniquets and splints | X | X | X | X | X | X | X | X |
| 11737200 Hemorrhage and bleeding and their arrest | X | X | X | X | X | X | X | X |
| 11737300 Handling and transportation of the sick or wounded | X | X | X | X | X | X | X | X |
| 11737400 Sprains, strains, fractures and their healing | X | X | X | X | X | X | X | X |
| 11737500 Foreign bodies not involving wounds in eye, throat | X | X | X | X | X | | X | |
| 11737600 Resuscitation | X | X | X | X | X | X | X | X |
| 11737700 Wounds and their healing (also includes operative incisions) | X | X | X | X | X | X | X | X |
| 11738000 Asepsis (concepts and techniques involved in achievement of sterile condition; includes concurrent and terminal disinfection during surgery, aspects of sterilization of implements and equipment such as autoclaving) | X | X | X | X | X | X | X | X |
| 11739000 Community health and preventive medicine | X | | | | | | | |
| 11739100 Treatment of social causes of illness (primary level of prevention) | X | | X | | | | | |
| 11739300 Rehabilitation and restoration of individual to community (tertiary level of prevention) | X | | X | | | | | |
| 11739430 Sanitation (establishment and maintenance of environmental conditions which are favorable to health; includes methods of waste disposal, sanitary considerations for food and drink, insect and rodent control) | X | X | X | X | | | | |
| 11741000 Epidemiology (relationship of factors which determine the frequencies and distributions of infectious processes, diseases or other pathological states, e.g., lead poisoning, in human communities; includes immunization) | X | X | X | X | | | | |
| 11742100 Physical therapy (excludes speech therapy and hearing therapy) | X | X | X | X | X | | X | |
| 11742110 Kinesiology and body mechanics | X | | X | | X | | X | |
| 11742120 Disability evaluation (testing and measurement to determine the extent and type of physical disability) | X | X | X | X | X | X | X | X |
| 11742131 Amputation adjustments (includes artificial limbs and their use; artificial organs and their use; excludes surgical procedures) | X | | X | | X | | X | |

APPENDIX B (continued)

| Knowledge Category Number and Name | | Run 1 | | Run 2 | | Run 3 | | Run 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | L | FA | L | FA | L | FA | L | FA |
| 11742132 | Corrective, preventive and compensatory adjustments (includes supportive and self-help devices and their use, such as wheelchairs, trusses, crutches and other mechanical devices and special measures to restore functioning, prevent malfunction, e.g., after surgery, and to make use of partial functions) | X | X | X | X | X | X | X | |
| 11742133 | Special post-disease and chronic disease therapy (special corrective procedures for the after-effects of diseases such as heart disease, rheumatic fever, epilepsy, blindness, diabetes, pulmonary tuberculosis) | X | X | X | X | X | X | X | X |
| 11742141 | Hydrotherapy (includes whirlpool baths) | X | | X | | X | | | |
| 11742143 | Heat therapy (includes diathermy, infrared, ultraviolet) | X | | X | | X | | | |
| 11742144 | Deep heat therapy (includes short wave, microwave, ultrasound) | X | | | | X | | | |
| 11742146 | Cold therapy (therapeutic use of cold) | X | | X | | | | | |
| 11742147 | Massage (systematic manipulation of body tissues for therapeutic purposes) | X | | X | | X | | X | |
| 11742148 | Exercise (corrective therapeutic and normal; includes active, passive and stretching, active assistance, isometric, progressive resistive (proprioceptive, isotonic), coordination and balance, breathing, prenatal and post partum, gait-training and locomotion exercise) | X | X | X | X | X | | X | |
| 11742151 | Vocational rehabilitation (only the physical therapy aspects) | X | | | | X | | | |
| 11742210 | Speech therapy | X | | X | | | | | |
| 11742220 | Hearing therapy | X | | X | | | | | |
| 11743000 | Nutrition and dietetics | X | | X | | X | | | |
| 11743100 | Biochemistry of nutrients (includes carbohydrates, fats, proteins, minerals, vitamins, water) | X | | X | | | | | |
| 11743200 | Physiology of nutrients (includes carbohydrates, fats, proteins, minerals, vitamins, water) | X | | X | | X | | | |
| 11743300 | Nutritional qualities of foods (includes losses resulting from processing, the relationship between foods their preparation and their nutritive content) | X | | X | | | | | |

APPENDIX B (continued)

| Knowledge Category Number and Name | | Run 1 | | Run 2 | | Run 3 | | Run 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | L | FA | L | FA | L | FA | L | FA |
| 11743400 | Nutritional requirements and diets (includes normal and therapeutic nutrition for adults, pregnancy and lactation, infancy, childhood, adolescence, and geriatrics) | X | X | X | X | X | X | X | X |
| 11744000 | Dentistry | X | | X | | X | X | X | X |
| 11741000 | Oral hygiene and care | X | | X | | | | | |
| 11744200 | Oral surgery (surgical and adjunctive treatment of diseases, injuries, and defects of the mouth, the jaws, and associated structures; includes fillings, pedontics, and corrective devices such as dentures, crowns, bridges) | X | | X | | X | | X | |
| 11744300 | Orthodontics (prevention and correction of irregularities of the teeth and malocclusion, and with associated facial problems) | X | | X | | X | | X | |
| 11745000 | Growth and development | X | X | X | X | X | X | X | X |
| 11745100 | Embryology and prenatal period growth and development | X | X | X | X | X | X | X | X |
| 11745200 | Neonatal period growth and development (birth through 1st month approximately) | X | X | X | X | X | X | X | X |
| 11745300 | Infant growth and development (2nd month through 2nd year approximately) | X | X | X | X | X | X | X | X |
| 11745400 | Childhood growth and development | X | X | X | X | X | X | X | X |
| 11745500 | Adolescent growth and development | X | X | X | X | X | X | X | X |
| 11745600 | Adulthood development | X | X | X | X | X | X | X | X |
| 11745700 | Old age (geriatrics) development | X | X | X | X | X | X | X | X |
| 11745800 | Death and dying development | X | X | X | X | | | | |
| 11800000 | Microbiology (includes physiology of microorganisms such as protozoa, fungi, algae, bacteria) | X | X | X | X | X | | X | |
| 11900000 | Molecular biology (includes viruses, the genetics of bacteria, and molecular and microbial genetics) | X | | X | | | | | |
| 12100000 | Cell biology (cytology and histology) | X | | X | | X | | X | |
| 12110000 | Cell morphology (structure) | X | | X | | | | | |
| 12120000 | Cell physiology | X | | X | | | | | |

APPENDIX B (continued)

| Knowledge Category Number and Name | Run 1 | | Run 2 | | Run 3 | | Run 4 | |
|---|---|---|---|---|---|---|---|---|
| | L | FA | L | FA | L | FA | L | FA |
| 12210000 Radiobiology (effects of high energy radiation on living organisms; includes effects of ionizing electromagnetic, ultraviolet, sonic and particulate radiation, biological safety requirements and protection) | X | X | X | X | X | X | X | X |
| 12220000 Radiology (diagnostic and therapeutic application of radiant energy including electromagnetic and particulate radiation) | X | X | X | X | X | X | X | X |
| 12221000 Radiotherapy (application of electromagnetic and particulate ionizing radiation to living organisms for therapeutic purposes; includes determination of course of treatment and administration of treatment) | X | X | X | X | X | X | X | X |
| 12222000 Radionuclide therapy (part of nuclear medicine; internal application of unsealed sources of particulate radiation (radioactive materials) to living organisms for therapeutic purposes; includes determination of course of treatment and use of radionuclides) | X | X | X | X | X | X | X | X |
| 12223000 Diagnostic radiography (application of electromagnetic ionizing radiation such as x-rays to achieve interpretable images for diagnostic purposes; also includes fluoroscopy, use of related techniques, contrast media, procedures, positioning, interpretation of images) | X | X | X | X | X | X | X | X |
| 12224000 Radionuclide analysis (part of nuclear medicine; internal application of unsealed radioactive nuclides to living organisms for the purpose of diagnosis or investigation; includes use of radioisotope scanning (tracer techniques), related procedures, positioning) | X | X | X | X | X | X | X | X |
| 12300000 Pharmacology (the study of drugs, i.e., chemical compounds or non-infectious biological substances which may be administered as an aid in the diagnosis, treatment or prevention of disease, for the relief of pain or suffering, or to control or improve any physiological or pathological condition) | X | X | X | X | X | X | X | X |
| 12311000 Drug receptor theory (includes bond types in drug receptor interaction) | X | | X | | | | | |

APPENDIX B (continued)

| Knowledge Category Number and Name | | Run 1 | | Run 2 | | Run 3 | | Run 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | L | FA | L | FA | L | FA | L | FA |
| 12312000 | Drug structure-activity relationships | X | | X | | | | | |
| 12313000 | Drug dose-response relationships | X | | X | | | | | |
| 12314000 | Non-receptor mediated drug action | X | | X | | | | | |
| 12321000 | Drug absorption (includes physiochemical nature of the drug, physiochemical nature of absorbing membrane, route of administration) | X | X | X | X | X | X | X | X |
| 12322000 | Drug distribution (includes volume of distribution, drug-plasma protein interaction, drug-membrane interactions, drug deposition and storage) | X | X | X | X | X | X | X | X |
| 12323000 | Drug excretion (includes physiochemical nature of the drug, routes of elimination) | X | X | X | X | X | X | X | X |
| 12324000 | Drug metabolism (includes oxidation, reduction, hydrolysis, conjugation) | X | X | X | X | X | X | X | X |
| 12331000 | Drug toxicity (includes antidotal therapy) | X | X | X | X | X | X | X | X |
| 12332000 | Drug idiosyncrasy and allergy pharmacogenetics (includes increased sensitivity to drugs, decreased responsiveness to drugs, novel drug effects, etc.; which are due to inherited physical characteristics) | X | X | X | X | X | X | X | X |
| 12333000 | Drug resistance (of a non-genetic nature; includes mutational origins) | X | | X | | | | | |
| 12334000 | Drug tolerance and physical dependence (includes homeostatic adjustment, cumulative effects, tolerance at the site of drug action) | X | X | X | X | X | | X | |
| 12335000 | Drug synergism (presence of two or more drugs in the body having interaction effects and the change in drug action this causes) | X | X | X | X | X | X | X | X |
| 12336000 | Chemical teratogenesis (special effects of drugs on the fetus during pregnancy) | X | X | X | X | X | X | X | X |
| 12341100 | Antibacterial and antifungal chemotherapy (includes antiseptics and germicides, sulfonamides, penicillins, erythromycin, tetracyclines and broad spectrum antibiotics, streptomycin, sulfones, antifungal agents) | X | X | X | X | X | X | X | X |

APPENDIX B (continued)

| Knowledge Category Number and Name | Run 1 | | Run 2 | | Run 3 | | Run 4 | |
|---|---|---|---|---|---|---|---|---|
| | L | FA | L | FA | L | FA | L | FA |
| 12341200 Antiprotozoal/antimetazoal chemotherapy (includes antimalarials, amebicides, heavy metals, metal-binding agents, antimonials anthelmintics) | X | X | X | X | X | | X | |
| 12341300 Cancer and virus chemotherapy (includes alkylating agents, antimetabolites, steroids and enzymes, interferon induction) | X | X | X | X | X | X | X | X |
| 12341400 Local chemotherapy (includes insecticides, repellents, and rodenticides, topical agents) | X | | X | | | | | |
| 12342100 Drugs acting on the cardiovascular system and smooth muscle (includes cardiac glycosides, quinidine and anti-arrhythmia agents, coronary vasodilators, diuretics, agents inhibiting the renal tubules, fluids (such as blood, substitutes, electrolytes), agents in atherosclerosis, hypotensive agents, smooth muscle relaxants, smooth muscle stimulants) | X | X | X | X | X | X | X | X |
| 12342200 Drugs acting on the blood (includes agents in anemia, anticoagulants and coagulants) | X | X | X | X | X | X | X | X |
| 12342300 Hormones and drugs acting on endocrine glands and accessory reproductive organs (includes adrenal cortical hormones and corticotropin, thyroid and thyrotropic hormones, sex hormones and gonadotropins, anterior pituitary, agents in diabetes mellitus, parathyroid hormone and calcium metabolism) | X | X | X | X | X | X | X | X |
| 12342400 Vitamins and nutritional agents (only pharmaceutical aspects; includes vitamins, agents in nutrition and obesity) | X | X | X | X | X | X | X | X |
| 12342500 Drugs influencing growth and development | X | | X | | X | | X | |
| 12342600 Drugs for allergy, cough, vomiting and the dermatomucosal surfaces (includes anti-immune drugs, antitussives, antiemetics, dermatomucosal agents) | X | X | X | X | X | X | X | X |
| 12342700 Drugs acting on the gastrointestinal tract (includes drugs effective in ulcer therapy, cathartics and laxatives, digestants and drugs useful in gallbladder disease) | X | X | X | X | X | X | X | X |
| 12342800 Drugs acting on the nervous system | X | X | X | X | X | X | X | X |
| 12342810 Drugs acting on the autonomic nervous system (includes sympathetic stimulants, sympathetic depressants, parasympathetic stimulants, parasympathetic depressants, ganglionic agents) | X | X | X | X | X | X | X | X |

APPENDIX B (continued)

| Knowledge Category Number and Name | | Run 1 | | Run 2 | | Run 3 | | Run 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | L | FA | L | FA | L | FA | L | FA |
| 12342820 | Drugs acting on the neuromuscular system (includes myoneural agents, muscle relaxants) | X | X | X | X | X | X | X | X |
| 12342830 | Drugs acting on the central nervous system (includes narcotic analgesics, non-narcotic analgesics, sedatives and hypnotics, anticonvulsants, tranquilizers, drug addiction, alcohol, psychomimetic agents, drugs affecting the mind) | X | X | X | X | X | X | X | X |
| 12342900 | Drugs acting on the immunologic system | X | | X | | X | | X | |
| 13310000 | Properties of elements (includes chemical and physical properties of the elements and their isotopes by the vertical groups of the periodic table, individual common light elements and heavier elements of specialized interest) | X | | X | | X | | X | |
| 13500000 | Properties of classes of compounds | X | | X | | X | | X | |
| 13900000 | Biochemical processes and mechanisms | X | | X | | | | | |
| 14111000 | Solutions (mechanical, optical, colligative properties; includes dilute, normal, molar, saturated and supersaturated solutions, whether liquid, solid or gaseous phase) | X | | X | | X | | X | |
| 14121000 | Mechanical analysis (tests of mechanical properties of matter; includes gravimetrics, weight and specific gravity, strength, hardness, brittleness, ductility; microscopic analysis of physical properties) | X | | X | | | | | |
| 14128000 | Separation methods in analysis (includes selective absorption, distillation and evaporation, extraction by solvents, separation by ion exchange, chromatography and diffusion analysis; precipitation methods) | X | | X | | | | | |
| 15212100 | Electric circuit theory (includes Ohm's law, Kirchhoff's laws, impedance, inductance, resistance, amperage, voltage, potentiometry, bridges, alternating and direct current, wave-guides, transmission) | X | X | X | X | X | X | X | X |
| 15222100 | Atomic structure (includes nuclear atom model; electronic energy levels, magnetic spin-orbit interaction) | X | | X | | X | | X | |

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APPENDIX B (continued)

| Knowledge Category Number and Name | Run 1 | | Run 2 | | Run 3 | | Run 4 | |
|---|---|---|---|---|---|---|---|---|
| | L | FA | L | FA | L | FA | L | FA |
| 15222200 Atomic radiation processes (includes ionization potentials, line spectra-transitions between electronic energy levels, forbidden lines, Zeeman effect, Stark effect, band structure-rotational spectra) | X | | X | | X | | X | |
| 15222500 Interaction with radiation (includes inversion spectra-absorption of microwave radiation) | X | X | X | X | X | X | X | X |
| 24110000 Electromagnetic field theory applications (includes electromagnetic devices and energy conversion) | X | | X | | X | | X | |
| 24112000 Transducers and rotating machines (includes electric motors, electric generators, relays, solenoids) | X | | X | | X | | X | |
| 24124000 Ultrasonics | X | X | X | X | X | X | X | X |
| 24130000 Electronics | X | | X | | | | | |
| 24132100 Electronic devices | X | X | X | X | X | X | X | X |
| 33000000 Computer technology | X | | X | | X | | X | |
| 41510000 Research design techniques | X | | X | | X | | X | |
| 41511000 Continuing study design (includes longitudinal studies) | X | | X | | X | | X | |
| 41512000 Descriptive study designs | X | | X | | X | | X | |
| 41513000 Experimental study designs (includes manipulative designs, after only, before-after, post-test control group, pre-test/post-test control group, multiple control group, Solomon Four Group design) | X | | X | | X | | X | |
| 41514000 Data collection methods | X | | X | | X | | X | |
| 41515000 Sampling methods (includes survey and other sampling methods) | X | | X | | X | | X | |
| 41520000 Intelligence and ability and their measurement | X | | X | | | | | |
| 41521200 Infant and preschool intelligence and their measurement | X | | X | | | | | |
| 41522000 Differential abilities and aptitudes and their measurement (includes tests of sensory capacities, motor functions, mechanical, clerical, artistic, musical aptitudes, literary appreciation, creativity, reasoning) | X | | X | | | | | |
| 41523000 Achievement and achievement measurement (includes tests of general educational development, achievement tests, proficiency examinations, performance evaluation, equivalency tests, licensure examinations) | X | | | | | | | |

APPENDIX B (continued)

| Knowledge Category Number and Name | | Run 1 | | Run 2 | | Run 3 | | Run 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | L | FA | L | FA | L | FA | L | FA |
| 41610000 | Sensation and perception | X | X | X | X | X | X | X | X |
| 41611100 | Auditory sensation (includes masking, pitch, loudness and attributes of tones) | X | | X | | X | | X | |
| 41611200 | Visual sensation | X | | X | | X | | X | |
| 41611300 | Cutaneous (touch) sensation | X | | X | | X | | X | X |
| 41611400 | Kinesthetic sensation (motion and location of body and body parts) | X | | X | | X | | X | X |
| 41611500 | Taste and smell sensation (chemically based senses) | X | | X | | X | | X | |
| 41612100 | Object perception and perceptual constancies | X | | X | | X | | X | |
| 41612200 | Selection, attention and set in perception | X | | X | | | | | |
| 41612300 | Perceptual organization (includes grouping, closure, figure and ground, distance and depth, direction and orientation, movement, form) | X | | X | | X | | X | |
| 41642000 | Sex drives (includes condition of arousal, selective and directional behavior, satiation and gratification of sex drives) | X | | X | | | | | |
| 41650000 | Emotions (includes conditions of arousal, disruptive and adaptive aspects of emotions, mood change) | X | | X | | | | | |
| 41660000 | Development and growth of behavioral processes of the individual | X | X | X | X | X | X | X | X |
| 41661000 | Motor development | X | | X | X | X | X | X | X |
| 41662000 | Perceptual development | X | | X | | X | | X | X |
| 41663000 | Cognitive development | X | | X | | X | | X | X |
| 41664000 | Language development | X | | X | | X | | X | |
| 41665000 | Emotional (affective) development | X | | X | | | | | |
| 41666100 | Infant behavioral development (also includes mother-child interaction, adaptive behavior) | X | | X | | | | | |
| 41666200 | Childhood behavioral development | X | | X | | | | | |
| 41666300 | Adolescent behavioral development | X | | X | | | | | |
| 41666400 | Young adulthood behavioral development | X | | X | | | | | |
| 41666500 | Adult behavioral development | X | | X | | | | | |
| 41666600 | Old age behavioral development | X | | X | | | | | |
| 41666700 | Death and dying behavioral development | X | X | X | X | X | X | X | X |

APPENDIX B (continued)

| Knowledge Category Number and Name | | Run 1 | | Run 2 | | Run 3 | | Run 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | L | FA | L | FA | L | FA | L | FA |
| 41690000 | Psychopathology | X | X | X | X | X | X | X | X |
| 41691000 | Mental retardation | X | X | X | X | X | X | X | X |
| 41692000 | Organic brain syndromes | X | | X | | X | X | X | X |
| 41693000 | Psychoses (includes schizophrenia, affective disorders, paranoid states; excludes psychoses of organic brain syndromes) | X | | X | | | | | |
| 41694000 | Neuroses | X | | X | | | | | |
| 41695100 | Personality disorders (includes personality disorders such as obsessive-compulsive, asthenic, passive-aggressive personality; excludes neuroses and psychoses) | X | | X | | | | | |
| 41695200 | Disorders involving addictive behavior (includes alcoholism, drug dependence) | X | | X | | | | | |
| 41696000 | Psychosomatic disorders (psychophysiological disorders) | X | | X | | | | | |
| 41697000 | Transient situational disturbances (temporary psychopathological disturbances due to acute situational stress) | X | | X | | | | | |
| 41710000 | Psychotherapy and counseling | X | X | X | X | | | | |
| 41711000 | Individual psychotherapy and counseling | X | | X | | | | | |
| 41720000 | Organic therapy (includes chemotherapy, insulin and sub-insulin shock therapy, electroshock therapy) | X | | X | | X | | X | |
| 41884000 | Social service administration and policy | X | | X | | | | | |
| 41884100 | Social services for the poor or indigent administration and policy (includes welfare) | X | | X | | | | | |
| 41884200 | Health services administration and policy (includes public, family health, hospital-based services) | X | X | X | X | X | | X | |
| 41884300 | Educational and training services administration and policy | X | | X | | | | | |
| 41884400 | Employment services administration and policy | X | | X | | | | | |
| 41884500 | Legal services administration and policy | X | | X | | | | | |
| 41884600 | Child care services administration and policy | X | | X | | | | | |
| 41884700 | Recreational services administration and policy | X | | X | | | | | |
| 41884800 | Special services for the aged or infirm administration and policy | X | | X | | | | | |
| 41884900 | Consumer protection services administration and policy | X | | X | | | | | |
| 41885100 | Social agencies (public and private) administration and policy | X | | X | | | | | |

APPENDIX B (continued)

| Knowledge Category Number and Name | | Run 1 | | Run 2 | | Run 3 | | Run 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | L | FA | L | FA | L | FA | L | FA |
| 42200000 | Curriculum design (includes subject, correlated, broad fields, core, experience, activity curriculum) | X | | | | | | | |
| 42300000 | Systems of content presentation (includes procedures such as lecture, symposium, panel, forum, role-playing, case study, demonstration, colloquium, audio-visual techniques, programmed instruction, micro-labs and laboratory methods) | X | X | X | | X | X | X | |
| 42630000 | Professional and graduate education | X | | X | | X | X | X | |
| 43700000 | Consumer economics (includes consumer protection, business practices related to consumer interests, money management for the household) | X | | X | | | | | |
| 51200000 | Algebra | X | X | X | X | X | X | X | X |
| 52200000 | Statistics | X | | X | | X | | X | |
| 52220000 | Descriptive statistics (includes standard frequency and distribution functions, measures of location such as mean, median, and mode, measures of dispersion, graphic and tabular representation of data) | X | | X | | X | X | X | X |
| 52230000 | Statistical design of experiments | X | | X | | X | | X | |
| 52240000 | Sampling theory (includes random, stratified, cluster, purposive sampling) | X | | X | | X | | X | |
| 52260000 | Statistical inference | X | | X | | X | | X | |
| 52262100 | Fixed sample size methods in hypothesis testing | X | | X | | X | | X | |
| 52263000 | Analysis of variance and covariance (includes linear and non-linear normal models) | X | | X | | X | | X | |
| 65260000 | Photography and cinematography | X | | X | | X | | X | |
| 65620000 | Mechanics of writing English (includes traditional (prescriptive) grammar, punctuation, spelling, bibliographic and footnote form) | X | X | X | X | X | X | X | X |
| 67510000 | Individual constitutional rights law | X | | X | | X | | X | |
| 69141220 | Articulatory phonetics (position, movement and condition of speech production parts and their effect on sound produced) | X | | X | | X | | X | |

APPENDIX B (continued)

| Knowledge Category Number and Name | Run 1 L | Run 1 FA | Run 2 L | Run 2 FA | Run 3 L | Run 3 FA | Run 4 L | Run 4 FA |
|---|---|---|---|---|---|---|---|---|
| 69163000 Psycholinguistic pathology (includes linguistic aspects of aphasia, mongoloidism, and other pathologies involving central nervous system, language learning and speech production of the deaf) | X | | X | | | | | |
| 69214200 Spanish | X | | X | | | | | |
| 71000000 Library science | X | | X | | X | | X | |
| 72000000 Cuisine | X | | X | | | | | |
| Skill and Knowledge Variables Included in Factor Analysis: | 144 | | 144 | | 144 | | 144 | |
| Total Skill and Knowledge Variables Identified: | 272 | | 267 | | 207 | | 201 | |

Selection detisions to reduce number of variables to 144 for factor analysis:

Run 1: Elimination of variables with frequencies across tasks of 24 or less, with two retained at 19, one at 18, and five deleted with frequencies above 24.

Run 2: Elimination at frequencies of 13 or less, with eleven deleted at frequencies above 13.

Run 3: Elimination at frequencies of 11 or less, with ten deleted at frequencies above 11.

Run 4: Elimination at frequencies at 7 or less, with thirteen deleted at frequencies above 7.

Note: Skills and knowledge categories are part of The Health Services Mobility Study Method of Task Analysis and Curriculum Design, Research Report No. 11, by Eleanor Gilpatrick, 1977.

APPENDIX C

HEALTH SERVICES MOBILITY STUDY SCALES

## Scale 1. TASK FREQUENCY

This scale refers to the frequency with which the task being scaled is executed by the performer. Tasks which are regularly done should be scaled by using the wording outside of the parentheses in the statements presented below. Tasks which are done infrequently or in concentrated periods during the year should be scaled by using the wording within the parentheses; the figures represent conversions to a normal work year.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0 | Task is never done. |
| 1 | Task is done once per year or less. |
| 2 | Task is done more often than once per year, but less than once per month (no more than 11 times per year). |
| 3 | Task is done once per month or more, but less often than once per week (no more than 33 times per year). |
| 4 | Task is done once per week or more, but less often than once per day (no more than 180 times per year). |
| 6 | Task is done once per day or more, but less often than five times per day (no more than 912 times per year). |
| 7 | Task is done five times per day or more, but less often than ten times per day (no more than 2,052 times per year). |
| 8 | Task is done ten times per day or more, but less often than fifty times per day (no more than 11,172 times per year). |
| 9 | Task is done fifty times per day or more (11,173 times per year or more). |

Note: This scale is not used for clustering tasks. Ratings on this scale are relevant only at the level of the institution.

## Scale 2. LOCOMOTION

This skill refers to the degree of body coordination required of a performer in the task being scaled. The skill involves the movement of the performer's body, torso or limbs through space in order to achieve predetermined standards of body movement or position.

The level of the skill rises with the degree of body coordination required. This is determined by the complexity of the standards involved, or the complexity of external conditions which restrict motion. The scale level is not determined by requirements for strength nor by the level of knowledge which may be required.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | The task does not require the performer to move his body, torso or limbs through spate so as to achieve a predetermined standard for body motion or position. |
| 1.5 | The task requires the performer to move his body, torso, or limbs through space so as to achieve simple, predetermined standard(s) for body motion or position. A small degree of body coordination is called for. |
| 5.0 | The task requires the performer to move his body, torso, or limbs through space so as to achieve somewhat complex, predetermined standards for body motion or position. A moderate degree of body coordination is called for. |
| 7.0 | The task requires the performer to move his body, torso or limbs through space so as to achieve considerably complex, predetermined standards for body motion or position. A high degree of body coordination is called for. |
| 9.0 | The task requires the performer to move his body, torso or limbs through space so as to achieve extremely complex, predetermined standards for body motion or position. An extremely high degree of body coordination is called for. |

## Scale 3. OBJECT MANIPULATION

This skill refers to the degree of control required of a performer in directly manipulating objects in the task being scaled. The skill involves the direct handling of objects using fingers, hands or limbs to achieve a predetermined standard.

The level of the skill rises with the degree of precision required and with the fineness of the manipulation involved. When fingers, hands or limbs manipulate an object in order to manipulate another object, the skill level reflects the direct manipulation involving the fingers, hands or limbs. The scale level is not determined by the level of knowledge needed to manipulate objects nor by the level of other manual skills or Figural Skills required.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | The task does not require the performer to directly handle objects with the fingers, hands or limbs so as to achieve a predetermined standard within constraints that require control and precision. |
| 1.5 | The task requires the performer to exercise a small amount of control and precision in directly manipulating objects with the fingers, hands or limbs in order to achieve a predetermined standard. Fairly gross motions are involved. |
| 3.5 | The task requires the performer to exercise a moderate amount of control and precision in directly manipulating objects with the fingers, hands or limbs in order to achieve a predetermined standard. Fairly gross motions are involved. |
| 5.0 | The task requires the performer to exercise a moderate amount of control and precision in directly manipulating objects with the fingers, hands or limbs in order to achieve a predetermined standard. Fairly fine motions are involved. |
| 7.5 | The task requires the performer to exercise a high degree of control and precision in directly manipulating objects with the fingers, hands or limbs in order to achieve a predetermined standard. Fairly fine motions are involved. |
| 9.0 | The task requires the performer to exercise a high degree of control and precision in directly manipulating objects with the fingers, hands or limbs in order to achieve a predetermined standard. Extremely fine motions are involved. |

## Scale 4. GUIDING OR STEERING

This skill refers to the degree of precision required of a performer in the task being scaled in moving an object over a predetermined pathway or holding steady on a moving target. The skill involves coordinating the performer's perceptions of external stimuli which tell him his position with his control of the object, in relation to the desired position or movement. The predetermined pathway or moving target may be actual or visualized.

The level of the skill rises as the precision needed rises (or the relative margin for error declines), and as the complexity of stimuli or the number of spatial directions or movements involved increase. The scale level is not determined by the degree of arm-hand steadiness involved, nor by the Figural Skills involved, nor by the level of knowledge required to accomplish the guiding or steering.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | The task does not require the performer to move an object over a predetermined pathway or hold steady on a moving target. |
| 1.5 | The task requires the performer to move an object over a predetermined pathway or hold steady on a moving target. The movement requires a small degree of precision within a fairly large, acceptable relative margin of error. The performer must pay attention to a small number of external stimuli and/or spatial directions. |
| 3.0 | The task requires the performer to move an object over a predetermined pathway or hold steady on a moving target. The movement requires a small degree of precision within a fairly large, acceptable relative margin of error. The performer must pay attention to a fairly complex set of external stimuli and/or spatial directions. |
| 5.5 | The task requires the performer to move an object over a predetermined pathway or hold steady on a moving target. The movement requires a considerable degree of precision within a narrow, acceptable relative margin of error. The performer must pay attention to a fairly complex set of external stimuli and/or spatial directions. |
| 7.0 | The task requires the performer to move an object over a predetermined pathway or hold steady on a moving target. The movement requires a considerable degree of precision within a narrow, acceptable relative margin of error. The performer must pay attention to an extremely complex set of external stimuli and/or spatial directions. |
| 9.0 | The task requires the performer to move an object over a predetermined pathway or hold steady on a moving target. The movement requires a very high degree of precision within an extremely narrow, acceptable relative margin of error. The performer must pay attention to an extremely complex set of external stimuli and/or spatial directions. |

## Scale 5. HUMAN INTERACTION

This skill refers to the degree of sensitivity to others required of the performer in the task being scaled. The skill involves the performer's perception of the relevant characteristics or state of being of the other person(s), the performer's attention to feedback as the interaction occurs, and the performer's appropriate modification of his behavior so as to accomplish the task. The skill is involved if the task requires any personal contact or interaction with others.

The level of the skill rises as the degree of perceptiveness and sensitivity required of the performer rises, and as the subtlety of the feedback to which he or she must respond increases. The scale level is not determined by the level of knowledge required.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | The task does not require the performer to be in contact with or to interact with other people. |
| 1.0 | The task requires the performer to be in only general contact with other people. Very little sensitivity to or perception of the other person(s)' relevant general characteristics or state of being is required, and little awareness of very obvious feedback is required for the performer to adjust his behavior to perform the task. |
| 3.0 | The task requires the performer to interact with others in the performance of the task. The performer is required to be somewhat sensitive to or perceptive of the other person(s)' relevant general characteristics or state of being, and to be aware of very obvious feedback so as to adjust his behavior accordingly. |
| 5.0 | The task requires the performer to interact with others in the performance of the task. The performer is required to be quite sensitive to or perceptive of the other person(s)' relevant characteristics or state of being, and to be aware of fairly obvious feedback so as to adjust his behavior accordingly. |
| 7.0 | The task requires the performer to interact with others in the performance of the task. The performer is required to be keenly sensitive to or perceptive of the other person(s)' relevant characteristics or state of being, and to be aware of fairly subtle or complex feedback so as to adjust his behavior accordingly. |
| 9.0 | The task requires the performer to interact with others in the performance of the task. The performer is required to be keenly sensitive to or perceptive of the other person(s)' relevant characteristics or state of being, and to be aware of very subtle or very complex feedback so as to adjust his behavior accordingly. |

## Scale 6. LEADERSHIP



This skill refers to the degree to which leadership in interacting with subordinates is required on the part of the performer in the task being scaled. The skill is involved when the performer's task requires him to interact with subordinates so as to affect their work performance in order for the performer to achieve goals related to the task. The subordinate relationship may be de facto as well as formal.

The level of this skill rises in relation to three aspects of the performer's relationship with subordinates which are relevant to the task situation. These are: (1) power over subordinates' conditions of employment; (2) clearness of mutual channels of communication; and (3) clearness of subordinates' own relevant task procedures.

Low levels of Leadership are required when the performer has a great deal of power over the subordinates' conditions of employment, when the performer has very formal and clearly defined channels of communication with the subordinates relevant to the task situation, and when the tasks of the subordinates related to the performer's objectives are very clear cut, obvious, and require little discretionary judgment.

High levels of Leadership are required when the performer's power is low, when channels of communication are vague and undefined, and when the relevant subordinates' tasks are vague and require a great deal of discretionary judgment.

The level of Leadership required for the task being scaled is determined by the combination of ratings of high, medium or low for each of the three aspects. The parentheses for each statement indicate the various combinations for each scale value.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | The task does not require the performer to relate to subordinates. |
| 1.0 | The task requires the performer to relate to subordinates in order to achieve work goals. The performer is understood to have a great amount of power over the related subordinates' conditions of employment. Channels of communication between the performer and the subordinates are very formalized and very well defined. The subordinates' related tasks are very clear cut, obvious and require little discretionary judgment. (Low range of Leadership needs on each of the three aspects. Also included: two lows and one medium.) |

(continued on next page)

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 3.0 | The task requires the performer to relate to subordinates in order to achieve work goals. The performer is understood to have a moderate amount of power over the related subordinates' conditions of employment. The channels of communication between the performer and the subordinates are somewhat formalized and moderately well defined. The subordinates' related tasks are very clear cut, obvious, and require little discretionary judgment. (Mid-range of Leadership needs on two out of the three aspects and low on a third. Also included, two lows and one high.) |
| 4.5 | The task requires the performer to relate to subordinates in order to achieve work goals. The performer is understood to have a moderate amount of power over the related subordinates' conditions of employment. The channels of communication between the performer and the subordinates are somewhat formalized and moderately well defined. The subordinates' related tasks are moderately clear cut, requiring some discretionary judgment. (Mid-range of Leadership needs on each of the three aspects. Also included: one low, one medium and one high; and two mediums and a high.) |
| 6.5 | The task requires the performer to relate to subordinates in order to achieve work goals. The performer is understood to have a moderate amount of power over the related subordinates' conditions of employment. The channels of communication between the performer and the subordinates are very informal, vague or irregular. The subordinates' related tasks are vaguely defined and require a great deal of discretionary judgment. (High rating for Leadership on two out of three aspects.) |
| 8.5 | The task requires the performer to relate to subordinates in order to achieve work goals. The performer is understood to have very little power over the related subordinates' conditions of employment. The channels of communication between the performer and the subordinates are very informal, vague or irregular. The subordinates' related tasks are vaguely defined and require a great deal of discretionary judgment. (High ratings for Leadership on all three aspects.) |

## Scale 7. ORAL USE OF A RELEVANT LANGUAGE

This skill refers to the level of precision in comprehension of heard language required of the performer in the task being scaled, and to the level of precision required in conveying meaning orally in the task situation. (The language referred to is the one in common use for the task.)

The level of this skill rises as the degree of precision in oral use of the language required in the task rises. The level of the scale is not determined by the knowledge reflected in the language used, nor by the skill of vocal delivery involved.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | The task does not require the performer to understand spoken language, or to speak. |
| 2.0 | The task requires the performer to understand and to convey meaning through the oral use of language. A low level of precision in choice of or comprehension of language is sufficient to accomplish the task. |
| 4.0 | The task requires the performer to understand and to convey meaning through the oral use of language. A moderate amount of precision in choice of or comprehension of language is necessary to accomplish the task. |
| 7.5 | The task requires the performer to understand and to convey meaning through the oral use of language. A fairly high degree of precision in choice of or comprehension of language is necessary to accomplish the task. |
| 9.0 | The task requires the performer to understand and to convey meaning through the oral use of language. A very high degree of precision and awareness of nuance in choice of or comprehension of language is necessary to accomplish the task. |

## Scale 8. READING USE OF A RELEVANT LANGUAGE

This skill refers to the level of comprehension required of the performer in his reading of written or printed material in the task being scaled. (The language referred to is the one in common use for the task.)

The level of this skill rises as the degree of precision in the reading use of the language required in the task rises. The level of this scale is not determined by the knowledge reflected in the material which is read.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | The task does not require the performer to read and understand written language. |
| 2.0 | The task requires the performer to read and comprehend the general meaning of simple written language. |
| 5.0 | The task requires the performer to read and comprehend the general meaning of moderately complex written language. |
| 7.0 | The task requires the performer to read and comprehend the general meaning of complex written language. |
| 9.0 | The task requires the performer to read and comprehend the precise meaning and nuance of complex written language. |

## Scale 9. WRITTEN USE OF A RELEVANT LANGUAGE

This skill refers to the level of precision required of the performer in conveying meaning in the task being scaled through the written use of language. (The language referred to is the one in common use for the task.)

The level of this skill rises as the degree of precision in the written use of the language required in the task rises. The level of this scale is not determined by the knowledge reflected in the language used, nor by the level of knowledge of grammar or of literary form required.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | The task does not require the performer to write language. |
| 2.0 | The task requires the performer to convey general meaning by writing in simple language. |
| 5.0 | The task requires the performer to somewhat precisely convey meaning by writing in moderately complex language. |
| 6.5 | The task requires the performer to fairly precisely convey meaning by writing in complex language. |
| 9.0 | The task requires the performer to very precisely convey meaning by writing in very complex language. |

## Scale 10. DECISION MAKING ON METHODS

This skill refers to the degree of responsibility required of a performer with respect to decisions he must make about how he does the task being scaled. How the task is done (the method) includes what is done, when, in what order, what is used, and who is involved. When the performer has any amount of latitude in deciding how to do the task, the skill is involved.

The skill rises as the choice of methods in the task situation are less and less obvious or specified; the skill rises as the circumstances of the task from one instance to another are more and more varied. The level of this scale is not determined by the level of knowledge required.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | The performer is not required to decide on how to do any part of the task. |
| 1.5 | The performer is required to decide how to do all or part of the task. Instances of the task vary little with respect to the methods to choose from, and once the situation is known, the performer's choice is obvious and/or specified. |
| 3.0 | The performer is required to decide how to do all or part of the task. Instances of the task vary little with respect to the methods to choose from, and the performer's choice is arrived at by referring to general guidelines for choosing an appropriate method. |
| 4.5 | The performer is required to decide how to do all or part of the task. Instances of the task vary somewhat with respect to the methods to choose from, and the performer's choice is arrived at by referring to general guidelines for choosing an appropriate method. |
| 7.0 | The performer is required to decide how to do all or part of the task. Instances of the task cover a wide range of circumstances calling for very different methods, and the performer's choice is arrived at by referring to general guidelines for choosing an appropriate method. |
| 9.0 | The performer is required to decide how to do all or part of the task. Instances of the task cover a wide range of circumstances calling for very different methods, and once the situation is assessed, the performer must make his choice by applying his own guidelines for selecting an appropriate method. |

## Scale 11. DECISION MAKING ON QUALITY

This skill refers to the degree of responsibility required of the performer with respect to decisions he must make about the quality of the output he produces in the task being scaled. The scale refers to the performer's latitude beyond the minimum acceptable levels of task performance. The skill is involved when the performer has any effect on the quality of the task's output beyond minimum requirements.

The skill rises with the extent to which the performer can affect the output's quality. It is also affected by whether or not the output is subject to review or inspection by others before it is used. The level of this scale is not determined by the level of knowledge required nor by the possibility of making errors.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | The performer is unable to affect the quality of the task's output. |
| 1.5 | The performer's exercise of choice in his standards of task performance can have only a minor effect on the quality of the task's output beyond minimum requirements, and the output is subject to complete and automatic review or inspection by someone else before it is used. |
| 2.0 | The performer's exercise of choice in his standards of task performance can have only a minor effect on the quality of the task's output beyond minimum requirements, and the output is subject to review or inspection by someone else before it is used. |
| 3.5 | The performer's exercise of choice in his standards of task performance can have only a minor effect on the quality of the task's output beyond minimum requirements, and the output is not subject to review or inspection by anyone else before it is used. |
| 5.5 | The performer's exercise of choice in his standards of task performance can have considerable effect on the quality of the task's output beyond minimum requirements, but the output is subject to review or inspection by someone else before it is used. |
| 7.0 | The performer's exercise of choice in his standards of task performance can have considerable effect on the quality of the task's output beyond minimum requirements, and the output is not subject to review or inspection by anyone else before it is used. |
| 9.0 | The performer's exercise of choice in his standards of task performance can completely determine the quality of the task's output due to the absence of minimum requirements, and the output is not subject to review or inspection by anyone else before it is used. |

## Scale 12. FIGURAL SKILLS

This skill refers to the level of complexity required of the performer in the task being scaled in dealing with figural aspects of materials. The skill involves the mental manipulation of figural properties in order to achieve a predetermined figural standard or objective. The figural aspects involved are limited to size, shape, form, or arrangement of materials in relation to space, whether the mental images involved or the materials dealt with are static or in motion. A figural standard would involve norms or criteria for size, shape, form or their arrangements in space.

The skill rises as the complexity of the figural standards which must be achieved to perform the task rise, and as the complexity of the figural relationships whose aspects the performer must deal with rise. The level of this scale is not determined by the level of knowledge nor by the level of manual skills required.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | The task does not require the performer to achieve a figural objective or standard involving size, shape, form, or arrangement of materials in relation to space, whether static or in motion. |
| 1.0 | The task requires the performer to achieve simple figural objectives, or meet simple figural standards involving the size, shape, form, or arrangement of materials in relation to space, whether static or in motion. The materials which are perceived or conceived of are dealt with in terms of their simple figural relationships. |
| 3.5 | The task requires the performer to achieve moderately complex figural objectives, or meet moderately complex figural standards involving the size, shape, form, or arrangement of materials in relation to space, whether static or in motion. The materials which are perceived or conceived of are dealt with in terms of their simple figural relationships. |
| 5.0 | The task requires the performer to achieve moderately complex figural objectives, or meet moderately complex figural standards involving the size, shape, form, or arrangement of materials in relation to space, whether static or in motion. The materials which are perceived or conceived of are dealt with in terms of their moderately complex figural relationships. |
| 7.0 | The task requires the performer to achieve moderately complex figural objectives, or meet moderately complex figural standards involving the size, shape, form, or arrangement of materials in relation to space, whether static or in motion. The materials which are perceived or conceived of are dealt with in terms of their highly complex figural relationships. |
| 9.0 | The task requires the performer to achieve highly complex figural objectives, or meet highly complex figural standards involving the size, shape, form, or arrangement of materials in relation to space, whether static or in motion. The materials which are perceived or conceived of are dealt with in terms of their highly complex figural relationships. |

## Scale 13. SYMBOLIC SKILLS

This skill is called for when the performer is required by the task being scaled to manipulate or use abstract symbols which are part of a system of symbolic notation. The skill involves the use of or manipulation of symbolic properties in such systems as numerical, musical, or code notations. The skill does not involve the semantic meaning or the figural properties of the symbols, nor use of single, one-to-one symbols which are not part of a system of notation, nor use of representational symbols.

The skill rises with the degree of complexity of the manipulation or use made of the symbols and with the complexity of the symbolic properties of the symbols. The level of this scale is not determined by the level of knowledge or subject matter represented by the symbols, nor by the figural properties of the symbols involved.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | The task does not require the performer to manipulate or use abstract symbols which are part of a system of notation. |
| 1.5 | The task requires the performer to manipulate or use in simple operation(s), simple abstract symbols which are part of a system of notation. |
| 3.5 | The task requires the performer to manipulate or use in simple operation(s), fairly complex, abstract symbols which are part of a system of notation. |
| 5.0 | The task requires the performer to manipulate or use in fairly complicated operations(s), fairly complex, abstract symbols which are part of a system of notation. |
| 7.0 | The task requires the performer to manipulate or use in fairly complicated operation(s), highly complex, abstract symbols which are part of a system of notation. |
| 9.0 | The task requires the performer to manipulate or use in highly complicated operation(s), highly complex, abstract symbols which are part of a system of notation. |

## Scale 14. TAXONOMIC SKILLS

This skill is called for when the performer is required by the task being scaled to consciously apply or create conceptual classifying or organizing principles. The skill involves the application of mental processes to assign an unknown set of information to existing conceptual classes or systems, or the creation of conceptual classes or systems to suit the needs of the task. The skill does not involve the use of intuitive judgment, the use of simply figural or symbolic principles, or the one-to-one matching of obvious characteristics.

When conceptual organizing or classifying principles are to be applied, the skill rises with the level of complexity of the principles. When conceptual organizing or classifying principles are to be created, the skill rises with the level of complexity of the purposes they must serve in the task. The level of this scale is not determined by the level of knowledge nor by the level of the other intellectual skills required.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | The task does not require the performer to consciously apply or create conceptual principles of classification or organization. |
| 2.0 | The task requires the performer to consciously apply simple conceptual principles of classification or organization; or to create conceptual principles with which to organize or classify information to suit simple needs in the task situation. |
| 5.5 | The task requires the performer to consciously apply somewhat complex conceptual principles of classification or organization; or to create conceptual principles with which to organize or classify information to suit somewhat complex needs in the task situation. |
| 7.0 | The task requires the performer to consciously apply considerably complex conceptual principles of classification or organization; or to create conceptual principles with which to organize or classify information to suit considerably complex needs in the task situation. |
| 9.0 | The task requires the performer to consciously apply extremely complex conceptual principles of classification or organization; or to create conceptual principles with which to organize or classify information to suit extremely complex needs in the task situation. |

## Scale 15. IMPLICATIVE SKILLS



This skill is called for when a performer must come to conclusions or draw implications in the task being scaled which go beyond the memorization of cause and effect relationships or simple associations. The skill involves the application of mental processes to deal with a set of information so as to draw non-routine conclusions or inferences or to foresee consequences in the performance of the task.

The skill rises with the degree of complexity of the information with which the performer must deal in drawing implications, and rises with the extent to which the kinds of information from which the conclusions or inferences are to be drawn vary from one instance of the task to another. The level of this scale is not determined by the seriousness of the errors in judgment which could be involved, nor by the level of knowledge, nor by the level of other intellectual skills required.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | The task does not require the performer to go beyond memorization of cause and effect relationships or simple associations to draw conclusions or inferences from a set of information. |
| 1.0 | The task requires the performer to go beyond memorization of cause and effect relationships or simple associations to draw conclusions or inferences from a set of relatively straight-forward or uncomplex information. The kinds of information from which the conclusions or inferences must be drawn vary little from one instance of the task to another. |
| 2.0 | The task requires the performer to go beyond memorization of cause and effect relationships or simple associations to draw conclusions or inferences from a set of relatively straight-forward or uncomplex information. The kinds of information from which the conclusions or inferences must be drawn vary somewhat from one instance of the task to another. |
| 4.0 | The task requires the performer to go beyond memorization of cause and effect relationships or simple associations to draw conclusions or inferences from a set of moderately complex information. The kinds of information from which the conclusions or inferences must be drawn vary little from one instance of the task to another. |
| 5.0 | The task requires the performer to go beyond memorization of cause and effect relationships or simple associations to draw conclusions or inferences from a set of moderately complex information. The kinds of information from which the conclusions or inferences must be drawn vary somewhat from one instance of the task to another. |

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| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 8.0 | The task requires the performer to go beyond memorization of cause and effect relationships or simple associations to draw conclusions or inferences from a set of extremely complex or extremely ambiguous information. The kinds of information from which the conclusions or inferences must be drawn vary somewhat from one instance of the task to another. |
| 9.0 | The task requires the performer to go beyond memorization of cause and effect relationships or simple associations to draw conclusions or inferences from a set of extremely complex or extremely ambiguous information. The kinds of information from which the conclusions or inferences must be drawn vary a great deal from one instance of the task to another. |

## Scale 16. FINANCIAL CONSEQUENCES OF ERROR

This skill refers to the degree of responsibility carried by a performer with respect to the financial damage which could result from errors in his performance of the task being scaled. The error whose consequences would be rated would be the most serious likely error to be expected from a performer qualified to do the task. The skill is involved if errors in performance of the task have any financial consequences involving any output, equipment, materials, time or other chargeable items. The level of this scale is not determined by the value of insurance claims or damage suits which would result from harm to humans.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | No likely error in the performer's task performance could result in financial damage to the institution. |
| 1.0 | The most serious likely error in the performer's task performance would result in negligible financial damage to the institution. |
| 4.0 | The most serious likely error in the performer's task performance would result in financial damage to the institution of a relatively moderate but manageable amount. |
| 6.0 | The most serious likely error in the performer's task performance would result in financial damage to the institution of an amount considered to be relatively difficult to absorb. |
| 7.5 | The most serious likely error in the performer's task performance would result in financial damage to the institution of an amount considered to be extremely serious and extremely difficult to absorb. |
| 9.0 | The most serious likely error in the performer's task performance would result in financial damge to the institution of an amount so serious that the institution would cease to exist. |

## Scale 17. CONSEQUENCES OF ERROR TO HUMANS

This skill refers to the degree of responsibility carried by the performer with respect to the harm which could be done to humans as a result of errors in his performance of the task being scaled. The error whose consequences are rated would be the most serious likely error to be expected from a performer qualified to do the task. The skill is involved if errors in performance of the task result in any physical or mental harm to humans, including recipients, respondents, co-workers, or persons not directly related to the task. The performer is included. The level of this scale is not determined by any financial harm which could be done to persons.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | No likely error in the performer's task performance could result in harm to a human. |
| 1.0 | The most serious likely error in the performer's task performance would result in physical or mental inconvenience. |
| 2.0 | The most serious likely error in the performer's task performance would result in very minor physical or mental harm, requiring little or no remediation. |
| 3.0 | The most serious likely error in the performer's task performance would result in minor physical or mental harm and would require remediation or treatment. |
| 5.5 | The most serious likely error in the performer's task performance would result in considerable physical or mental harm and would require remediation or treatment. |
| 7.0 | The most serious likely error in the performer's task performance would result in very serious physical or mental harm, or would put the affected person in danger of minor permanent damage. |
| 8.0 | The most serious likely error in the performer's task performance would result in serious permanent damage beyond the help of remediation or treatment. |
| 9.0 | The most serious likely error in the performer's task performance would result in immediate and inevitable death. |

## Scale 18. LEVELS OF KNOWLEDGE



This scale refers to the level of knowledge in a given subject category required of the performer in the task being scaled. The knowledge category is rated with this scale. To be rated above zero on the scale the task must require knowledge beyond the simple memorization of the overt steps of the task.

The scale rises with the amount of detailed knowledge which must be consciously applied and with the depth of understanding required in the subject area, in terms of the subject area's content, the structure of its ideas, and its uses. "Detailed knowledge" covers such things as technical or special terms or facts. "Consciously applied" means that the performer is able to (but need not) articulate his use of the knowledge in the task situation.

The level of knowledge for a category is not determined by the level of any intellectual skills required, nor by the level for any other knowledge category required for the task, nor by the level of the category required for any other tasks of the job involved.

| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 0.0 | The task does not require the performer to consciously apply knowledge in this subject category which has been gained in a learning experience requiring more than the memorization of the overt steps of the specific task being scaled. |
| 1.5 | The task requires that the performer consciously apply a limited amount of detailed knowledge in this subject category, including such things as technical or special terms, facts or equipment. |
| 2.5 | The task requires that the performer have a general awareness of this subject category in terms of its content, the structure of its ideas, and its uses. The performer must consciously apply a limited amount of detailed knowledge in this subject area, including such things as technical or special terms, facts or equipment. |
| 3.5 | The task requires that the performer have a general awareness of this subject category in terms of its content, the structure of its ideas, and its uses. The performer must consciously apply a moderate amount of detailed knowledge in this subject area, including such things as technical or special terms, facts or equipment. |

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| SCALE VALUE | DESCRIPTIVE STATEMENT |
|---|---|
| 5.5 | The task requires that the performer have a considerable degree of understanding of this subject category in terms of its content, the structure of its ideas, and its uses. The performer must consciously apply a moderate amount of detailed knowledge in this area, including such things as technical or special terms, facts or equipment. |
| 7.0 | The task requires that the performer have a considerable degree of understanding of this subject category in terms of its content, the structure of its ideas, and its uses. The performer must consciously apply a very great amount of detailed knowledge in this subject area, including such things as technical or special terms, facts or equipment. |
| 8.0 | The task requires that the performer have a very deep understanding of this subject category in terms of its content, the structure of its ideas, and its uses. The performer must consciously apply a moderate amount of detailed knowledge in this subject area, including such things as technical or special terms, facts or equipment. |
| 9.0 | The task requires that the performer have a very deep understanding of this subject category in terms of its content, the structure of its ideas, and its uses. The performer must consciously apply a very great amount of detailed knowledge in this subject area, including such things as technical or special terms, facts or equipment. |

APPENDIX D

SUMMARY OF TWO-MODE FACTOR ANALYSIS RESULTS

Table D.1. FACTOR STRUCTURE OF SKILL AND KNOWLEDGE VARIABLES



| Skill or Knowledge Category Number and Abbreviated Name[c] | Loadings of Skill and Knowledge Variables[a] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Run 1 Factors[b] | | | | | | | Run 4 Factors[b] | | | | | |
| | I | II | III | IV | V | VI | VII | I | II | IV | V | III | VI |
| Object Manipulation Skills | | | | .64 | | | | | | .58 | | | |
| Guiding or Steering Skills | | | | .63 | | | | | | .49 | | .48 | |
| Human Interaction Skills | | | | .49 | | | | | | | | .72 | |
| Oral Use of a Relevant Language | .56 | | | | | | .42 | .48 | | | | .70 | |
| Reading Use of a Relevant Language | .49 | | | | | | .57 | | | | | .69 | |
| Written Use of a Relevant Language | .67 | | | | | | | .65 | | | | .56 | |
| Decision Making on Methods | | | | | | | | | | | | .53 | |
| Decision Making on Quality | .42 | | | | | | | | | | | .49 | |
| Figural Skills | .72 | | | | | | | .61 | | | | .67 | |
| Symbolic Skills | | | | .45 | | | .59 | | | | | .72 | |
| Taxonomic Skills | .61 | | | | | | .42 | .53 | | | | .67 | |
| Implicative Skills | .71 | | | | | | | .72 | | | | .53 | |
| Financial Consequences of Error | | | | | | | .45 | | | | | | .54 |
| Consequences of Error To Humans | | | | .58 | | | | | | | | .66 | |
| 11731000 Normal structure and function | .83 | | | | | | | .88 | | | | | |
| 11731100 Regional anatomy | .61 | | | .42 | | | | .54 | | | | .72 | |
| 11731200 Topographic anatomy | .49 | | | .62 | | | | | | | | .74 | |
| 11731300 Hematopoietic system | .89 | | | | | | | .92 | | | | | |

[a] Loadings of .40 or more are shown. Negative sign indicates that variable loads inversely with respect to loading of other variables that determine the factor.

[b] Refers to analysis of 144 skill and knowledge variables for each run as presented in Appendix B. Run 1 refers to 560 tasks in ambulatory care and diagnostic radiology; Run 4 refers to 324 tasks in diagnostic radiology excluding teaching and meetings tasks. Appendix A presents abbreviated task names and the tasks in each run.

[c] See Appendix B for full names of the knowledge categories. See Appendix C for skill scales.

Note: Factors were assigned the same number across runs when the structure was similar. Factor names by run, number, and content are as follows:

Run 1 7-Factor Solution

- I Non-neurologic radiology.
- II Diagnosis, neuroradiology.
- III Ambulatory care examinations, counseling, administration, conferences, meetings.
- IV Patient and emergency care.
- V Female care and obs-gyn. radiology.
- VI Gastrointestinal care and radiology.
- VII Radiologic technology, quality assurance, materials-related.

Run 4 6-Factor Solution

- I Non-neurologic radiology.
- II Neuroradiology.
- III * See below.
- IV Patient and emergency care.
- V Obstetrics-gynecology radiology.
- VI * See below.
- III * Radiologic technology.
- VI * Quality assurance, materials-related.

Table D.1 (continued)



| Knowledge Category Number and Abbreviated Name[c] | Loadings of Skill and Knowledge Variables[a] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Run 1 Factors[b] | | | | | | | Run 4 Factors[b] | | | | | |
| | I | II | III | IV | V | VI | VII | I | II | IV | V | III | VI |
| 11731400 Circulatory system | .76 | | | | | | | .84 | | | | | |
| 11731500 Respiratory system | .79 | | | | | | | .91 | | | | | |
| 11731600 Digestive system | .83 | | | | | | | .96 | | | | | |
| 11731610 Mouth, pharynx, esophagus | .42 | | | | | .76 | | .59 | | | | | |
| 11731620 Stomach and small intestine | | | | | | .80 | | .57 | | | | | |
| 11731630 Large intestine (colon) and rectum | | | | | | .80 | | .58 | | | | | |
| 11731640 Liver, biliary system, and pancreas | | | | | | .78 | | .51 | | | | | |
| 11731700 Urinary system | .80 | | | | | | | .88 | | | | | |
| 11731800 Musculo-skeletal system | .74 | | | | | | | .69 | | | | .60 | |
| 11731810 Muscles | .69 | | | | | | | .85 | | | | | |
| 11731820 Bones and joints | .69 | | | | | | | .64 | | | | .62 | |
| 11731831 Skin and sweat glands | x | x | x | x | x | x | x | .85 | | | | | |
| 11731900 Nervous system | .81 | | | | | | | .90 | | | | | |
| 11731910 Central nervous system | | .76 | | | | | | | .81 | | | | |
| 11731920 Peripheral nervous system | | .78 | | | | | | | .82 | | | | |
| 11731930 Autonomic nervous system | .47 | .58 | | | | | | .52 | .52 | | | | |
| 11731943 Eye and optic nerve | | .72 | | | | | | | .90 | | | | |
| 11731944 Touch, heat, cold and pain receptors | x | x | x | x | x | x | x | | .94 | | | | |
| 11731945 The ear | | .73 | | | | | | | .91 | | | | |
| 11731946 Kinesthetic receptors | x | x | x | x | x | x | x | | .93 | | | | |
| 11732100 Immunologic system | .84 | | | | | | | .87 | | | | | |
| 11732210 Endocrine glands and hormone physiology | .80 | | | | | | | .91 | | | | | |
| 11732220 Reproduction | | | .46 | | .72 | | | | | | .83 | | |
| 11732221 Conception and contraception | | | .57 | | .52 | | | | | | .68 | | |
| 11732222 Male reproductive system | .75 | | .40 | | | | | .88 | | | | | |
| 11732223 Female reproductive system | .69 | | | | .49 | | | | | | | | |

x: not included for this run's factor analysis.

Table D.1 (continued)

| Knowledge Category Number and Abbreviated Name[c] | Loadings of Skill and Knowledge Variables[a] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Run 1 Factors[b] | | | | | | | Run 4 Factors[b] | | | | | |
| | I | II | III | IV | V | VI | VII | I | II | IV | V | III | VI |
| 11732300 Homeostasis of fluids | .80 | | | | | | | .89 | | | | | |
| 11732400 Metabolism | .75 | | | | | | | .88 | | | | | |
| 11733000 Pathology | .86 | | | | | | | .93 | | | | | |
| 11733100 Infective and parasitic diseases | .82 | | | | | | | .95 | | | | | |
| 11733200 Neoplasms (cancerous growths) | .85 | | | | | | | .86 | | | | | |
| 11733300 Endocrine, nutritional, metabolic disorders | .81 | | | | | | | .92 | | | | | |
| 11733400 Disorders of blood, blood-forming organs | .90 | | | | | | | .91 | | | | | |
| 11733510 Disorders of central nervous system | .79 | | | | | | | .86 | | | | | |
| 11733520 Disorders of peripheral nervous system | .74 | .43 | | | | | | .82 | .40 | | | | |
| 11733530 Disorders of autonomic nervous system | .81 | | | | | | | .90 | | | | | |
| 11733543 Disorders of eye, optic nerve | | .59 | .58 | | | | | | .86 | | | | |
| 11733544 Disorders of touch,heat,cold,pain receptors | x | x | x | x | x | x | x | | .93 | | | | |
| 11733545 Disorders of the ear | | .62 | .58 | | | | | | .91 | | | | |
| 11733546 Disorders of kinesthetic receptors | x | x | x | x | x | x | x | | .93 | | | | |
| 11733600 Disorders of the circulatory system | .73 | | | .40 | | | | .72 | | | | .50 | |
| 11733700 Disorders of the digestive system | .84 | | | | | | | .93 | | | | | |
| 11733800 Disorders of the respiratory system | .76 | | | | | | | .77 | | | | .51 | |
| 11733900 Disorders of the uro-genital system | .81 | | | | | | | .87 | | | | | |
| 11734100 Disorders of skin, subcutaneous tissues | .69 | | | | | | | .87 | | | | | |
| 11734200 Disorders of musculoskeletal system | .78 | | | | | | | .74 | | | | .56 | |
| 11734300 Congenital abnormalities | .89 | | | | | | | .92 | | | | | |
| 11734400 Disorders, complications of pregnancy,birth | .66 | | | | .47 | | | .72 | | | .42 | | |
| 11734500 Perinatal morbidity and mortality | | | | | .61 | | | | | | .73 | | |
| 11734600 Burns | .75 | | | | | | | .88 | | | | | |
| 11734700 Poisoning | .80 | | | | | | | .91 | | | | | |
| 11734800 Shock and trauma | .63 | | | .58 | | | | .60 | | | | .66 | |
| 11735000 Surgery | .84 | | | | | | | .93 | | | | | |
| 11735100 Operative procedures | .86 | | | | | | | .92 | | | | | |
| 11735200 Amputation and disarticulation | x | x | x | x | x | x | x | | | | | | |
| 11735300 Repair surgery | .90 | | | | | | | .92 | | | | | |
| 11735400 Introductory procedures | .70 | | | | | | | .71 | | .40 | | | |

Table D.1 (continued)



| Knowledge Category Number and Abbreviated Name[c] | Loadings of Skill and Knowledge Variables[a] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Runs 1 Factors[b] | | | | | | | Run 4 Factors[b] | | | | | |
| | I | II | III | IV | V | VI | VII | I | II | IV | V | III | VI |
| 11735500 Endoscopy | .59 | | | | | | | .61 | | | | | |
| 11735600 Suture | | | | | .50 | | | x | x | x | x | x | x |
| 11735700 Manipulation | | .44 | | | .45 | | | | | | | | |
| 11735800 Delivery methods for childbirth | | | .43 | | .62 | | | | | | .79 | | |
| 11736000 Anesthesiology | .54 | | | | | | | .44 | | .54 | | | |
| 11737000 First aid and care | | | | .59 | | | | | | .54 | | | |
| 11737100 Bandages, dressings, tourniquets, splints | | | | .53 | | | | | | .67 | | | |
| 11737200 Hemorrhage and bleeding and their arrest | | | | .45 | .42 | | | .44 | | .55 | | | |
| 11737300 Handling, transportation of sick, wounded | | | | .75 | | | | | | | | .77 | |
| 11737400 Sprains, strains, fractures, healing | .69 | | | .46 | | | | .64 | | | | .60 | |
| 11737500 Foreign bodies in eye, throat | | | .40 | | | .44 | | x | x | x | x | x | x |
| 11737600 Resuscitation | | | | .52 | | | | | | .57 | | | |
| 11737700 Wounds and their healing | .53 | | | .55 | | | | .58 | | | | .60 | |
| 11738000 Asepsis | | | | .74 | | | | | | .46 | | .66 | |
| 11739430 Sanitation | | | .69 | | | | | x | x | x | x | x | x |
| 11741000 Epidemiology | | | .86 | | | | | x | x | x | x | x | x |
| 11742100 Physical therapy | | .48 | .48 | | | | | x | x | x | x | x | x |
| 11742120 Disability evaluation | | .62 | | | | | | | .68 | | | | |
| 11742132 Corrective, preventive, compensatory adjustments | | | .52 | | | | | x | x | x | x | x | x |
| 11742133 Special post-disease, chronic disease therapy | .53 | | | | | | | .54 | | | | | |
| 11742148 Exercise | | | .53 | | | | | x | x | x | x | x | x |
| 11743400 Nutritional requirements and diets | .50 | | .40 | | | | | .66 | | | | | |
| 11744000 Dentistry | x | x | x | x | x | x | x | | | | | | |
| 11745000 Growth and development | .74 | | | | | | | .92 | | | | | |
| 11745100 Embryology, prenatal growth, development | | | | | .59 | | | .40 | | | | | |
| 11745200 Neonatal period growth, development | .52 | | | | | | | .66 | | | | | |
| 11745300 Infant growth, development | .69 | | | | | | | .78 | | | | | |
| 11745400 Childhood growth; development | .74 | | | | | | | .80 | | | | | |
| 11745500 Adolescent growth, development | .79 | | | | | | | .88 | | | | | |

Table D.1 (continued)



| Knowledge Category Number and Abbreviated Name[c] | Loadings of Skill and Knowledge Variables[a] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Run 1 Factors[b] | | | | | | | Run 4 Factors[b] | | | | | |
| | I | II | III | IV | V | VI | VII | I | II | IV | V | III | VI |
| 11745600 Adulthood development | .72 | | | | | | | .75 | | | | | |
| 11745700 Old age (geriatrics) development | .71 | | | | | | | .75 | | | | | |
| 11745800 Death and dying development | | | | | .40 | .41 | | x | x | x | x | x | x |
| 11800000 Microbiology | | | .57 | | | | | x | x | x | x | x | x |
| 12210000 Radiobiology | .57 | | | | | | .58 | | | | | .84 | |
| 12220000 Radiology | .92 | | | | | | | .90 | | | | | |
| 12221000 Radiotherapy | .94 | | | | | | | .92 | | | | | |
| 12222000 Radionuclide therapy | .95 | | | | | | | .92 | | | | | |
| 12223000 Diagnostic radiography | .60 | | | | | | .59 | .42 | | | | .80 | |
| 12240000 Radionuclide analysis | .72 | | | | | | | .56 | | | | | |
| 12300000 Pharmacology | .78 | | | | | | | .92 | | | | | |
| 12321000 Drug absorption | .71 | | | | | | | .82 | | | | | |
| 12322000 Drug distribution | .71 | | | | | | | .82 | | | | | |
| 12323000 Drug excretion | .65 | | | | | | | .70 | | .44 | | | |
| 12324000 Drug metabolism | .40 | .59 | | | | | | | | .64 | | | |
| 12331000 Drug toxicity | .55 | | | | | | | .54 | | .59 | | | |
| 12332000 Drug idiosyncrasy, allergy pharmacogenetics | .56 | | | | | | | .53 | | .59 | | | |
| 12334000 Drug tolerance and physical dependence | | .44 | | | .48 | .46 | | x | x | x | x | x | x |
| 12335000 Drug synergism | .72 | | | | | | | .88 | | | | | |
| 12336000 Chemical teratogenesis | .78 | | | | | | | .83 | | | | | |
| 12341100 Antibacterial and antifungal chemotherapy | .55 | | | | | | | .58 | | .48 | | | |
| 12341200 Antiprotozoal/antimetazoal chemotherapy | | | | | | .61 | | x | x | x | x | x | x |
| 12341300 Cancer and virus chemotherapy | .86 | | | | | | | .88 | | | | | |
| 12342100 Drugs acting on the cardiovascular system and smooth muscle | .44 | .42 | | | | | | .46 | | .67 | | | |
| 12342200 Drugs acting on the blood | | .54 | | | | | | | | .68 | | | |
| 12342300 Hormones and drugs acting on endocrine glands, accessory reproductive organs | | .48 | | | .47 | | | | | .51 | | | |
| 12342400 Vitamins and nutritional agents | | | | | | .41 | | .41 | | .57 | | | |
| 12342600 Drugs for allergy, cough, vomiting | .67 | | | | | | | .66 | | .50 | | | |
| 12342700 Drugs acting on gastrointestinal tract | .48 | | | | | .55 | | .66 | | | | | |

Table D.1 (continued)



| Knowledge Category Number and Abbreviated Name[c] | Loadings of Skill and Knowledge Variables[a] | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Run 1 Factors[b] | | | | | | | Run 4 Factors[b] | | | | | | |
| | I | II | III | IV | V | VI | VII | I | II | IV | V | III | VI | |
| 12342800 Drugs acting on the nervous system | .43 | .65 | | | | | | | .47 | .56 | | | | |
| 12342810 Drugs acting on autonomic nervous system | .60 | .44 | | | | | | .61 | | .43 | | | | |
| 12342820 Drugs acting on the neuromuscular system | .44 | .64 | | | | | | | .46 | .56 | | | | |
| 12342830 Drugs acting on the central nervous system | .72 | | | .41 | | | | .68 | | | | .44 | | |
| 15212100 Electric circuit theory | | | | | | | .59 | | | | | | .80 | |
| 15222500 Interaction with radiation | | | | | | | .77 | -.50 | | | | .66 | | |
| 24124000 Ultrasonics | .74 | | | | | | | .58 | | | .44 | | | |
| 24132100 Electronic devices | | | | | | | .58 | | | | | | .75 | |
| 41610000 Sensation and perception | | .66 | | | | | | | .95 | | | | | |
| 41611300 Cutaneous, (touch) sensation | x | x | x | x | x | x | x | | .92 | | | | | |
| 41611400 Kinesthetic sensation | x | x | x | x | x | x | x | | .92 | | | | | |
| 41660000 Development, growth of behavioral processes of the individual | | | .78 | | | | | | .93 | | | | | |
| 41661000 Motor development | x | x | x | x | x | x | x | | .92 | | | | | |
| 41662000 Perceptual development | x | x | x | x | x | x | x | | .89 | | | | | |
| 41663000 Coghitive development | x | x | x | x | x | x | x | | .89 | | | | | |
| 41666700 Death and dying behavioral development | .56 | | | | | | | .40 | | | | .45 | | |
| 41690000 Psychopathology | | | .81 | | | | | | .91 | | | | | |
| 41691000 Mental retardation | .77 | | | | | | | .79 | | | | | | |
| 41692000 Organic brain syndromes | x | x | x | x | x | x | x | | .91 | | | | | |
| 41710000 Psychotherapy and counseling | | | .83 | | | | | x | x | x | x | x | x | |
| 41884200 Health services administration and policy | | | .74 | | | | | x | x | x | x | x | x | |
| 42300000 Systems of content presentation | | | | | | | | x | x | x | x | x | x | |
| 51200000 Algebra | | | | | | | .50 | | | | | | | |
| 52220000 Descriptive statistics | x | x | x | x | x | x | x | | | | | | | |
| 65620000 Mechanics of writing English | .61 | | | | | | .48 | .56 | | | | .69 | .70 | |
| Total Variables in Factor at ± .40 or Higher: | 91 | 20 | 18 | 18 | 13 | 10 | 12 | 92 | 24 | 22 | 6 | 30 | 4 | |
| Percentage Variance Accounted for by Factor: | 34 | 8 | 7 | 7 | 6 | 6 | 4 | 38 | 14 | 7 | 4 | 10 | 3 | |
| | Run 1 7-Factor Solution | | | | | | | Run 4 6-Factor Solution | | | | | | |
| Total Variance Accounted for by Factor Solution: | 71% | | | | | | | 76% | | | | | | |
| Number of Variables unassigned at ± .40 or higher: | 2 | | | | | | | 4 | | | | | | |

Note: All the skill and knowledge variables identified for all the tasks are presented in Appendix B.

Table D.2. ASSIGNMENT OF TASKS TO FACTORS BY TASK CODE AND FACTOR NUMBER



| Task Code | Six-Factor Solution[a] I | II | III | IV | V | VI | A |
|---|---|---|---|---|---|---|---|
| **TASKS IN DIAGNOSTIC RADIOLOGY** | | | | | | | |
| 1 | x | | | | | | |
| 2 | x | | | | | | |
| 3 | x | | | | | | |
| 4 | x | | | | x | | |
| 5 | x | | | | x | | |
| 6 | x | | | | | | |
| 7 | | | x | | | | |
| 8 | | | | | | x | |
| 18 | | | | x | | | |
| 19 | | | | x | | | |
| 20 | x | | | | | | |
| 33 | | | | x | | | |
| 65 | | | | x | | | |
| 66 | x | | | | | | |
| 67 | x | | | | | | |
| 68 | x | | | | | | |
| 69 | | | | | | x | |
| 70 | | | | | | x | |
| 71 | | | | | | x | |
| 72 | | | | | | x | |
| 73 | | | | x | | | |
| 74 | | | | x | | | |
| 76 | | | | | | | x |
| 77 | | | | x | | | |
| 78 | | | | | | x | |
| 79 | | | | | | x | |
| 80 | | | | | | x | |
| 81 | | | x | | | | |
| 82 | | | x | | | | |
| 95 | | | | | | x | |
| 98 | | | | x | | | |
| 113 | | | | x | | | |
| 128 | | | | | | | x |
| 129 | | | | | | | x |
| 131 | | | | | | | x |
| 132 | | | | | | | x |
| 133 | | | | | x | | |
| 134 | | | | | | x | |
| 135 | | | | | | x | |
| 136 | | | | | | x | |
| 137 | | | | | | x | |
| 138 | | | | | x | | |
| 143 | | | | | x | | |
| 145 | | | | | | x | |
| 147 | | | | | | x | |
| 153 | | | | | x | | |
| 155 | | | | | x | | |
| 156 | | | | | x | | |
| 158 | | | | | x | | |
| 163 | | | | | | x | |
| 164 | | | | | | x | |
| 165 | | | | | | | x |
| 166 | | | | | x | | |
| 167 | | | | | | x | |
| 173 | | | | | | x | |
| 175 | | | | | | x | |
| 178 | | | | | | x | |
| 180 | | | | | | x | |
| 181 | | | | | x | | |
| 182 | | | | | x | | |

[a] Factors are as follows: (Based on Run 4)

| | | No. of Tasks |
|---|---|---|
| Factor I: | Non-neurologic radiology. | 128 |
| Factor II: | Neuroradiology. | 20 |
| Factor III: | Radiologic technology. | 77 |
| Factor IV: | Patient and emergency care. | 51 |
| Factor V: | Obstetric-gynecologic radiology. | 16 |
| Factor VI: | Quality assurance, materials-related. | 83 |
| Non-factor A: | Administration. | 14 |

| Task Code | Six-Factor Solution[a] I | II | III | IV | V | VI | A | Task Code | Six-Factor Solution[a] I | II | III | IV | V | VI | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TASKS IN DIAGNOSTIC RADIOLOGY (continued) | | | | | | | | | | | | | | | |
| 184 | | | | | | x | | 291 | | | | x | | | |
| 185 | | | | x | | | | 292 | | | | x | | | |
| 186 | | | | | | | x | 293 | | | | | | | x |
| 187 | | | | | | x | | 294 | | | | | | | x |
| | | | | | | | | 295 | | | | x | | | |
| 190 | | | | x | | | | 296 | | | | x | | | |
| | | | | | | | | 297 | | | | | | x | |
| 192 | | | | | | x | | 298 | | | | x | | | |
| 193 | | | | x | | | | 299 | | | | x | | | |
| | | | | | | | | 300 | | | | | | x | |
| 198 | | | | x | | | | 301 | | | | x | | | |
| 199 | | | | x | | | | 302 | | | | x | | | |
| | | | | | | | | 303 | | | | x | | | |
| 222 | | | | | | x | | 304 | | | | | | x | |
| 223 | | | | | | x | | 305 | | | | x | | | |
| | | | | | | | | 306 | | | | | | | x |
| 227 | | | | | | x | | 307 | | | | | | | x |
| | | | | | | | | 308 | | | | x | | | |
| 243 | | | | x | | | | 309 | | | | | | | x |
| | | | | | | | | 310 | | x | | | | | |
| 260 | | | | | | x | | 311 | | x | | | | | |
| | | | | | | | | 312 | | x | | | | | |
| 262 | | | | x | | | | 313 | | x | | | | | |
| | | | | | | | | 314 | | x | | | | | |
| 264 | | | | | | x | | 315 | | x | | | | | |
| | | | | | | | | 316 | | x | | | | | |
| 267 | | | | | | x | | 317 | | x | | | | | |
| | | | | | | | | 318 | | x | | | | | |
| 269 | | | | | | x | | 319 | | x | | | | x | |
| | | | | | | | | 320 | | x | | | | | |
| 271 | | | | x | | | | 321 | | x | | | | | |
| 272 | | | | | | | x | 322 | | x | | | | | |
| 273 | | | | | | x | | 323 | | x | | | | | |
| 274 | | | | | | x | | 324 | | x | | | | | |
| 275 | | | | | | x | | 325 | | x | | | | | |
| 276 | | | | | | x | | 326 | | x | x | | | x | |
| 277 | | | | | | | x | 327 | | x | x | | | x | |
| 278 | | | | x | | | | 328 | | x | | | | | |
| 279 | | | | x | | | | 329 | | x | | | | | |
| 280 | | | x | x | | x | | 330 | | x | | | | | |
| 281 | | | | x | | | | 331 | | x | | | | | |
| 282 | | | | x | | | | 332 | | x | | | | | |
| 283 | | | | x | | | | 333 | | x | | | | | |
| 284 | | | | | | x | | 334 | | x | | | | | |
| 285 | | | | | | x | | 335 | | x | | | | | |
| 286 | | | | | | x | | 336 | | x | | | | | |
| 287 | | | | x | | | | 337 | | x | | | | | |
| 288 | | | | | | x | | 338 | | x | | | | | |
| 289 | | | | x | | | | 339 | | x | | | | | |
| 290 | | | | x | | | | 340 | | x | | | | | |

Table D.2 (continued)



| Task Code | Six-Factor Solution[a] I | II | III | IV | V | VI | A | Task Code | Six-Factor Solution[a] I | II | III | IV | V | VI | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TASKS IN DIAGNOSTIC RADIOLOGY (continued) | | | | | | | | | | | | | | | |
| 341 | x | | | | | | | 391 | | x | | | | | |
| 342 | x | | | | | | | 392 | | x | | | | | |
| 343 | x | | | | | | | 393 | | x | | | | | |
| 344 | x | | | | | | | 394 | | x | | | | | |
| 345 | x | | | | | | | 395 | | x | | | | | |
| 346 | x | | | | | | | 396 | | | x | | | | |
| 347 | x | | | | | | | 397 | | | x | | | | |
| 348 | x | | | | | | | 398 | | | x | | | | |
| 349 | x | | | | | | | 399 | | | x | | | | |
| 350 | x | | | | | | | 400 | | | x | | | | |
| 351 | x | | | | | | | 401 | | | x | | | | |
| 352 | x | | | | | | | 402 | | x | | | | x | |
| 353 | | | x | | | | | 403 | | x | | | | x | |
| 354 | | | | | | x | | 404 | | | x | | | | |
| 355 | | | x | | | | | 405 | | | x | | | | |
| 356 | | | x | | | | | 406 | | x | | | | x | |
| 357 | | | x | | | | | 407 | | | x | | | | |
| 358 | | | x | | | | | 408 | | | x | | | | |
| 359 | | | x | | | | | 409 | | x | | | | | |
| 360 | | | x | | | | | 410 | | x | | | | | |
| 361 | | | x | | | | | 411 | | x | | | | | |
| 362 | | | x | | | | | 412 | | x | | | | | |
| 363 | | | x | | | | | 413 | | x | | | | | |
| 364 | | | x | | | | | 414 | | x | | | | | |
| 365 | | | x | | | | | 415 | | x | | | | | |
| 366 | | | x | | | | | 416 | | x | | | | | |
| 367 | | | x | | | | | 417 | | x | | | | | |
| 368 | | | x | | | | | 418 | | x | | | | x | |
| 369 | | | x | | | | | 419 | | x | | | | x | |
| 370 | | | x | | | | | 420 | | x | | | | x | |
| 371 | | | x | | | | | 421 | | x | | | | x | |
| 372 | | | x | | | | | 422 | | x | | | | x | |
| 373 | | | x | | | | | 423 | | x | | | | x | |
| 374 | | | x | | | | | 424 | | x | | | | x | |
| 375 | | | x | | | | | 425 | | x | | | | x | |
| 376 | | | x | | | | | 426 | | x | | | | | |
| 377 | | | x | | | | | 427 | | | x | | | | |
| 378 | | | x | | | | | 428 | | | x | | | | |
| 379 | | | x | | | | | 429 | | | x | | | | |
| 380 | | | x | | | | | 430 | | | x | | | | |
| 381 | | | x | | | | | 431 | | | x | | | | |
| 382 | | | x | | | | | 432 | | | x | | | | |
| 383 | | | x | | | | | 433 | | x | | | | | |
| 384 | | | x | | | | | 434 | | x | | | | | |
| 385 | | | x | | | | | 435 | | x | | | | | |
| 386 | | | x | | | | | 436 | | x | | | | | |
| 387 | | | x | | | | | 437 | | x | | | | | |
| 388 | | | x | | | | | 438 | | x | | | | | |
| 389 | | | x | | | | | 439 | | x | x | | | x | |
| 390 | | | x | | | | | 440 | | | x | | | | |

| Task Code | Six-Factor Solotion[a] | | | | | | | Task Code | Six-Factor Solution[a] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | A | | I | II | III | IV | V | VI | A |
| TASKS IN DIAGNOSTIC RADIOLOGY (continued) | | | | | | | | | | | | | | | |
| 441 | x | | | | | | | 491 | | | x | | | | |
| 442 | x | | | | | | | 492 | | | x | | | | |
| 443 | x | | | | | | | 493 | | | x | | | | |
| 444 | x | | | | | | | 494 | | | x | | | | |
| 445 | x | | | | | | | 495 | | | x | | | | |
| 446 | x | | | | | | | 496 | | | x | | | | |
| 447 | x | | | | | | | 497 | | | x | | | | |
| 448 | x | | | | | | | 498 | | | x | | | | |
| 449 | x | | | | | | | 499 | | | x | | | | |
| 450 | x | | | | | | | 500 | | | x | | | | |
| 451 | x | | | | | | | 501 | | | x | | | | |
| 452 | x | | | | | | | 502 | | | x | | | | |
| 453 | x | | | | | | | 503 | | | x | | | | |
| 454 | x | | | | | | | 504 | | | x | | | | |
| 455 | x | | | | | | | 505 | | | x | | | | |
| 456 | x | | | | | | | 506 | | | x | | | | |
| 457 | x | | | | | | | 507 | | | x | | | | |
| 458 | x | | | | | | | 508 | | | x | | | | |
| 459 | x | | | | | | | 509 | | | x | | | | |
| 460 | x | | | | | | | 510 | | | x | | | | |
| 461 | x | | | | | | | 511 | | | x | | | | |
| 462 | x | | | | | | | 512 | | | x | | | | |
| 463 | | | x | | | | | 513 | | | x | | | | |
| 464 | | | x | | | | | 514 | | | x | | | | |
| 465 | | | x | | | | | 515 | | | x | | | | |
| 466 | | | x | | | | | 516 | | | x | | | | |
| 467 | | | x | | | | | 517 | | | x | | | | |
| 468 | | | x | | | | | 518 | | | x | | | | |
| 469 | x | | | | | | | 519 | | | x | | | | |
| 470 | x | | | | | | | 520 | | | | x | | | |
| 471 | x | | | | | | | 521 | | | | x | | | |
| 472 | x | | | | | | | 522 | | | | x | | | |
| 473 | x | | | | | | | 523 | | | | | | | x |
| 474 | x | | | | | | | 524 | | | | | | | x |
| 475 | x | | | | | | | 525 | | | | | | | x |
| 476 | x | | | | | | | 526 | | | x | | | | |
| 477 | x | | | | | | | 527 | | | | | | | x |
| 478 | x | | | | | | | 528 | | | | | | | x |
| 479 | x | | | | | | | 529 | | | | | | | x |
| 480 | x | | | | | | | 530 | | | | | | | x |
| 481 | x | | | | | | | 531 | | | | | | | x |
| 482 | x | | | | | | | 532 | | | | | | | x |
| 483 | x | | | | | | | 533 | | | | | | | x |
| 484 | x | | | | | | | 534 | | | | | | | x |
| 485 | x | | | | | | | 535 | | | | | | | x |
| 486 | x | | | | | | | 536 | | | | | | | x |
| 487 | x | | | | | | | 537 | | | | | | | x |
| 488 | x | | | | | | | 538 | | | | | | | x |
| 489 | x | | | | | | | 539 | | | | | | | x |
| 490 | | | | x | | | | 540 | | | | | | | x |

| Task Code | Six-Factor Solution[a] I | II | III | IV | V | VI | A | Task Code | Six-Factor Solution[a] I | II | III | IV | V | VI | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TASKS IN DIAGNOSTIC RADIOLOGY (continued) | | | | | | | | | | | | | | | |
| 541 | | | | | | x | | 551 | | | | | | x | |
| 542 | | | | | | x | | 552 | | | | | | x | |
| 543 | | | | | | x | | 553 | | | | | | x | |
| 544 | | | | | | x | | 554 | | | | | | x | |
| 545 | | | | | | x | | 555 | | | | | | x | |
| 546 | | | | | | x | | 556 | | | | | | x | |
| 547 | | | | | | x | | 557 | | | | | | x | |
| 548 | | | | | | x | | 558 | | | | | | x | |
| 549 | | | | | | x | | 559 | | | | | | x | |
| 550 | | | | | | x | | 560 | | | | | | x | |

| Task Code | Seven-Factor Solution[b] B | I | II | III | IV | V | VI | VII | Task Code | Seven-Factor Solution[b] B | I | II | III | IV | V | VI | VII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TASKS FOUND SOLELY IN AMBULATORY CARE | | | | | | | | | | | | | | | | | |
| 9 | | | x | | | | | | 39 | | | | x | | x | | |
| 10 | | | x | | | | | | 40 | | | x | | | x | | |
| 11 | | | | x | | | | | 41 | | | | | | x | | |
| 12 | | | | | x | | | | 42 | | | | | | x | | |
| 13 | | | | | x | | | | 43 | | | | | | x | | |
| 14 | x | | | | | | | | 44 | | | | | | x | | |
| 15 | x | | | | | x | | | 45 | | | | | | x | | |
| 16 | x | | | | | x | | | 46 | | | | | | x | | |
| 17 | | | | | x | | | | 47 | | | | | | x | | |
| | | | | | | | | | 48 | | | | | | x | | |
| 21 | | | x | | | | | | 49 | | | | | | x | | |
| 22 | | | | | x | | | | 50 | | | | | | x | | |
| 23 | | | | x | | | | | 51 | x | | | | | x | | |
| 24 | | | | x | | | | | 52 | | | | x | | x | | |
| 25 | | | | x | | | | | 53 | | | | x | | x | | |
| 26 | | | | x | | | | | 54 | | | | x | | x | | |
| 27 | | | | x | | | | | 55 | | | x | x | | | | |
| 28 | | | | | x | | | | 56 | | | x | | | | | |
| 29 | | | | x | | | | | 57 | | | | | x | | | |
| 30 | | | | | x | | | | 58 | | | | | x | | | |
| 31 | | | | | x | | | | 59 | | | | | x | | x | |
| 32 | | | | | x | | | | 60 | | | | | x | | | |
| | | | | | | | | | 61 | | | | | x | | | |
| 34 | | | | | x | | | | 62 | | | | | x | | | |
| 35 | x | | | | | | | | 63 | | | | x | | | | |
| 36 | x | | | | | | | | 64 | | | | x | | | | |
| 37 | | | | | x | | | | | | | | | | | | |
| 38 | | | x | | x | | | | 75 | | | | x | | | | |

[b] Factors are as follows: (Based on Run 1)

| | |
|---|---|
| Factor I: | Non-neurologic radiology (none solely in ambulatory care). |
| Factor II: | Diagnosis, neuroradiology. |
| Factor III: | Ambulatory care examinations, counseling, administration, conferences. |
| Factor IV: | Patient and emergency care. |
| Factor V: | Female care (obs-gyn.). |
| Factor VI: | Gastrointestinal care. |
| Factor VII: | Radiologic technology, quality assurance, materials. |
| Non-Factor B: | Laboratory procedures. |

| Task Code | Seven-Factor Solution[b] | | | | | | | Task Code | Seven-Factor Solution[b] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B | I | II | III | IV | V | VI | VII | | B | I | II | III | IV | V | VI | VII |
| TASKS FOUND SOLELY IN AMBULATORY CARE (continued) | | | | | | | | | | | | | | | | | |
| 83 | | | | x | | | | | 144 | | | | | | | | x |
| 84 | | | | x | | x | | | | | | | | | | | |
| 85 | | | | x | | x | | | 146 | | | | | | | | x |
| 86 | | | | x | | x | | | | | | | | | | | |
| 87 | | | | x | x | | | | 148 | | | | x | | | | |
| 88 | | | | x | | | | | 149 | | | | | | | | x |
| 89 | | | | x | | | | | 150 | | | | | | | | x |
| 90 | | | | x | | | | | 151 | | | | | | | | x |
| 91 | | | | | x | | | | 152 | | | | | x | | | |
| 92 | | | | | x | | | | | | | | | | | | |
| 93 | | | | | x | | | | 154 | | | | x | | | | |
| 94 | | | | x | | | | | | | | | | | | | |
| | | | | | | | | | 157 | | | | | | | | x |
| 96 | | | | | x | | | | | | | | | | | | |
| 97 | | | | x | x | | | | 159 | | | | x | | | | |
| | | | | | | | | | 160 | | | | | x | | | |
| 99 | | | | x | x | | | | 161 | | | | | x | | | |
| 100 | | | | x | | | | | 162 | | | | | x | | | |
| 101 | | | | x | | x | | | | | | | | | | | |
| 102 | | | | x | | | | | 168 | | | | | | | | x |
| 103 | | | | | | x | | | 169 | | | | | | | | x |
| 104 | | | | | x | | | | 170 | | | | | x | | | |
| 105 | | | | | x | | | | 171 | | | | x | | | | |
| 106 | | | | x | x | | | | 172 | x | | | | | | x | |
| 107 | | | | x | | x | | | | | | | | | | | |
| 108 | | | | x | | | | | 174 | | | | | | | | x |
| 109 | | | | | x | | x | | | | | | | | | | |
| 110 | | | | x | | | | | 176 | | | | | | | | x |
| 111 | | | | x | | | | x | 177 | | | | | x | | | |
| 112 | | | | x | x | | | | | | | | | | | | |
| | | | | | | | | | 179 | | | | | | | | x |
| 114 | | | | x | | | | | | | | | | | | | |
| 115 | | | | x | | | | | 183 | | | | | x | | | |
| 116 | | | | x | | | | | | | | | | | | | |
| 117 | | | | | x | | | | 188 | | | | | x | | | |
| 118 | | | | x | x | | | | 189 | | | | | x | | | |
| 119 | | | | x | | | | | | | | | | | | | |
| 120 | | | | x | | | | | 191 | | | | | x | | | |
| 121 | | | | x | | | | | | | | | | | | | |
| 122 | | | | x | | | | | 194 | | | | | x | | | |
| 123 | | | | x | | | | | 195 | | | | | x | | | |
| 12 | | | | x | | | | | 196 | | | | x | x | | | |
| [illegible] | | | | x | | | | | 197 | | | | x | | | | |
| 126 | | | | x | | | | | | | | | | | | | |
| 127 | | | | x | | | | | 200 | | | | | x | | | |
| | | | | | | | | | 201 | | | | | x | | | |
| 130 | | | | | | | | x | 202 | | | | x | | x | | |
| | | | | | | | | | 203 | | | | x | | | | |
| 139 | | | | x | x | | | | 204 | | | | x | | | | |
| 140 | | | | x | x | | | | 205 | | | | | x | | x | |
| 141 | x | | | | | | x | | 206 | | | | | x | | | |
| 142 | | | | | x | | x | | 207 | x | | | | | | | |

Table D.2 (continued)

| Task Code | Seven-Factor Solution[b] | | | | | | | | Task Code | Seven-Factor Solution[b] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B | I | II | III | IV | V | VI | VII | | B | I | II | III | IV | V | VI | VII |
| TASKS FOUND SOLELY IN AMBULATORY CARE (continued) | | | | | | | | | | | | | | | | | |
| 208 | | | | | | | | x | 240 | | | | x | | | | |
| 209 | | | | | x | | | | 241 | | | | x | | | | |
| 210 | | | | | x | | | | 242 | | | | x | | | | |
| 211 | | | | x | x | | | | | | | | | | | | |
| 212 | | | | | x | | | | 244 | | | | x | x | | | |
| 213 | | | | | x | | | | 245 | | | | x | | | | |
| 214 | | | | | x | | | | 246 | | | | x | | | | |
| 215 | | | | x | | | | | 247 | | | | x | | | | |
| 216 | | | | x | | | | | 248 | | | | x | | x | | |
| 217 | | | | | x | | | | 249 | | | | x | | x | | |
| 218 | | | | | x | | | | 250 | | | | x | | | | |
| 219 | | | | x | | | | | 251 | | | | x | | | | |
| 220 | | | | x | x | | | | 252 | | | | x | | | | |
| 221 | | | | x | | | | | 253 | | | | x | | | | |
| | | | | | | | | | 254 | | | | x | | | | |
| 224 | | | | | | | | x | 255 | | | | x | | | | |
| 225 | | | | | | | | x | 256 | | | | | x | | | |
| 226 | | | | x | | x | | | 257 | | | | x | x | | | |
| | | | | | | | | | 258 | | | | x | | x | | |
| 228 | | | | x | | | | | 259 | | | | x | | | | |
| 229 | | | | | x | | x | | | | | | | | | | |
| 230 | | | | | | | | x | 261 | | | | x | | | | |
| 231 | | | | | | | | x | 263 | | | | | x | | | x |
| 232 | | | | | x | | | | | | | | | | | | |
| 233 | | | | x | | | | | 265 | | | | | | | | x |
| 234 | | | | x | x | | | | 266 | | | | | | | | x |
| 235 | | | | x | | | | | | | | | | | | | |
| 236 | | | | x | | | | | 268 | | | | | | | | x |
| 237 | | | | x | | | | | | | | | | | | | |
| 238 | | | | x | | | | | 270 | | | | x | x | | | |
| 239 | | | | x | | | | | | | | | | | | | |

Note: The abbreviated task names are listed by task code number in Appendix A.

APPENDIX E

FACTOR STRUCTURE OF TASKS:
THE ARRANGEMENT OF TASKS WITHIN FACTORS

Table E.1. FACTOR STRUCTURE OF TASKS: QUALITY ASSURANCE FACTOR



| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[c] |
|---|---|---|---|
| | **Level 5 (Professional)** | | |
| 559 | Planning and presenting lectures and/or related laboratory sessions on radiation and/or health physics for students in professional programs for diagnostic radiology, in medical school, or in medical sciences. | .37 | x |
| 557 | Collecting and presenting technical information about and/or recommending new diagnostic x-ray equipment. | .38 | .57 |
| 528 | Designing, maintaining, evaluating calibration and/or dose monitoring program in diagnostic radiology. | .42 | .59 |
| 546 | Designing, maintaining, evaluating radiation protection and monitoring programs in diagnostic radiology. | .43 | .59 |
| 547 | Determining primary and secondary structural shielding required for diagnostic x-ray installations. | .33 | .44 |
| 542 | Designing, maintaining, evaluating darkroom and/or film processor monitoring program in diagnostic radiology. | .32 | .52 |
| 558 | Providing clinical training for staff in a diagnostic radiology department in quality assurance tests of equipment, in radiation protection procedures, and related maintenance. | .29 | x |
| 560 | Preparing lectures or participating in meetings of staff members in diagnostic radiology on radiation protection and quality assurance requirements and practices. | .30 | x |
| 555 | Investigating reasons for reported high occupational radiation exposure and initiating remediation. | .15 | .21 |
| 541 | Evaluating accepted and rejected radiographs to identify any technical problems with staff functioning, equipment, radiation protection. | .20 | .23 |

[a] An "x" in column means that task was not included in the run.

[b] Factor VII of 7; combined factor incorporating radiologic technology and quality assurance tasks.

[c] Factor VI of 6; quality assurance tasks.

Note: Tasks are arranged in descending order within levels by difficulty as reflected in the number of skill and knowledge categories required and the scale values at which the categories are required. Factor loadings run from high, positive values, through zero, to negative values (for lower-level tasks).

Table E-1, (continued)



| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[c] |
|---|---|---|---|
| | Level 2 (Technician) | | |
| 535 | Performing calibration tests of kVp, mA, mAs, exposure rates, reproducibility on diagnostic radiography equipment using direct measuring instruments and/or radiographic comparisons. | .22 | .41 |
| 550 | Conducting protection survey of stray radiation within diagnostic x-ray installation and transmission across primary and secondary protective barriers. | .15 | .17 |
| 545 | Monitoring patient exposure rates for routine diagnostic x-ray procedures. | .13 | .14 |
| 543 | Monitoring and evaluating x-ray film processors. | .12 | .28 |
| 544 | Determining exposure characteristics of x-ray and/or dosimetric films. | .06 | .16 |
| 532 | Checking and/or performing direct calibration tests of diagnostic radiography equipment exposure timers. | .18 | .25 |
| 537 | Checking diagnostic tomography x-ray equipment for mechanical operation, fulcrum position, resolution, exposure uniformity and/or grid alignment. | .06 | .06 |
| 548 | Checking maximum entrance exposure rate and primary barrier transmitted radiation rate for fluoroscopic equipment. | .12 | .16 |
| 529 | Checking x-ray field limitation, x-ray receptor and light field alignment, minimum TOD, TFD and field size indicators for diagnostic x-ray equipment. | .10 | .08 |
| 530 | Checking fluoroscopic and spot film x-ray field limitations, x-ray field and image receptor alignment, maximum TID, minimum TOD, and other requirements. | .10 | .08 |
| 531 | Testing whether diagnostic x-ray tube overload protection and/or effective focal spot size meet acceptable standards. | .06 | .07 |
| 549 | Checking the leakage radiation rate from the source assembly of diagnostic x-ray equipment. | .12 | .16 |
| 540 | Checking fluoroscopic automatic brightness control system and/or focus, resolution and distortion of the optical system. | .05 | .06 |
| 525 | Checking calibration and accuracy of C.T.T. equipment by making test scans. | .03 | .06 |
| 539 | Checking bucky grid alignment and/or centering in diagnostic radiography equipment. | .03 | .05 |

Table E.1 (continued) 

| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[c] |
|---|---|---|---|
| | Level 2 (Technician) continued | | |
| 556 | Calibrating diagnostic x-ray test, survey, or measuring instruments. | .16 | .26 |
| 533 | Checking automatic exposure termination of diagnostic radiography equipment. | .04 | .06 |
| 538 | Estimating HVL and checking adequacy of filtration of diagnostic x-ray equipment. | .03 | .16 |
| 175 | Performing penetrometer calibration test of kVp or mA selectors of x-ray machine output. | .05 | .09 |
| 553 | Reading and recording exposure from personnel monitoring film or thermoluminescent dosimeters. | -.02 | .13 |
| 534 | Providing visual and radiographic or fluoroscopic inspection of personnel shielding devices such as leaded gloves, aprons, sheets, gonadal shields. | -.01 | .03 |
| 178 | Checking, preparing fluoroscope controls (and phototimer). | .03 | .10 |
| 527 | Retrieving, displaying and making photographs, printouts and/or magnetic tape records of computerized transverse axial tomographic (C.T.T.) scans. | -.03 | .01 |
| 536 | Providing visual and/or manual inspection of diagnostic radiography system. | .02 | .11 |
| 173 | Checking accuracy of x-ray machine timers (except phototimers) with spinning top test. | -.01 | .03 |
| 524 | Providing preventive maintenance for display tube surface, camera, disc and/or tape drive units, and/or scanning assembly (especially water-using head box assembly) of computerized transverse axial tomography (C.T.T.) equipment. | -.04 | -.00 |
| 276 | Making minor adjustments or repair on automatic x-ray film processor. | -.03 | .07 |
| 554 | Entering, evaluating occupational radiation exposure data and initiating action on dangerous levels. | -.02 | .03 |
| 280 | Participating in monitoring of personal exposure to radiation by periodically turning in and replacing film strip in badge worn by performer. | -.02 | .01 |
| 187 | Checking cassettes for proper film-screen contact. | -.04 | -.01 |

| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[c] |
|---|---|---|---|
| | **Level 2 (Technician) continued** | | |
| 523 | Preparing computerized transverse axial tomography (C.T.T.) equipment for use. | -.06 | .00 |
| 78 | Checking and jacketing patient's radiographs, ultrasonograms, and/or C.T.T. scans with requisition sheets and prior diagnostic materials and placing for filing or interpreting. | -.06 | .00 |
| | **Level 1 (Aide)** | | |
| 304 | Readying emergency cart. | -.09 | -.02 |
| 147 | Preparing or changing technique charts for specific x-ray and fluoroscopic equipment on orders. | -.02 | .06 |
| 192 | Inspecting, checking, preparing xeroradiography equipment for use. | -.08 | -.02 |
| 80 | Preparing materials or trays with medications and materials for special treatments or procedures according to standard orders. | -.08 | -.02 |
| 273 | Cleaning, inspecting and readying automatic x-ray film processor(s) for use. | -.08 | .00 |
| 71 | Processing exposed x-ray film manually. | -.08 | -.01 |
| 8 | Shutting down computerized transverse axial scanning equipment | -.07 | -.01 |
| 70 | Inspecting, cleaning and readying x-ray film hand processing equipment for use. | -.08 | -.01 |
| 275 | Preparing radiographic subtraction prints. | -.09 | .02 |
| 69 | Processing exposed x-ray film in automatic processor.* | -.11 | -.04 |
| 552 | Collecting and/or distributing personnel monitoring dosimetric badge inserts and preparing for outside or in-house processing and reading. | -.11 | -.04 |
| 354 | Obtaining patient records for use in examination, procedure, treatment or conference. | -.09 | -.01 |
| 284 | Checking presence and functioning of oxygen and/or suction equipment and amounts of oxygen. | -.10 | -.02 |
| 95 | Testing a urine sample by tablet or dipstick method and recording. | -.10 | -.02 |
| 260 | Preparing a hypodermic needle with injection dosage on orders.* | -.11 | -.05 |
| 79 | Preparing barium sulfate contrast medium as ordered or for standard use.* | -.12 | -.05 |

* See note at end of table.

| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[c] |
|---|---|---|---|
| | **Level 1 (Aide) continued** | | |
| 134 | Logging and/or tallying patient services and/or instructional case record materials for use in record keeping, billing or instruction. | -.07 | .00 |
| 135 | Cleaning an examination or treatment room after use. | -.09 | -.01 |
| 227 | Checking for presence and condition of emergency supplies in proper locations; and restocking as needed. | -.09 | -.01 |
| 72 | Loading x-ray film cassette(s), nonscreen film holder(s), box(es), and/or roll film cartridges. | -.12 | -.04 |
| 551 | Preparing personnel radiation monitoring dosimetric film or TLD badges and distributing.* | -.14 | -.05 |
| 136 | Checking and storing order for non-narcotic drugs and/or supplies. | -.10 | -.03 |
| 269 | Loading empty cassette with Polaroid x-ray film.* | -.12 | -.05 |
| 180 | Preparing blood samples for the laboratory.* | -.14 | -.08 |
| 286 | Filling out standard order for linen; picking up, folding and storing.* | -.11 | -.04 |
| 145 | Preparing treatment or examination equipment for sterilization in autoclave.* | -.14 | -.06 |
| 274 | Adding predetermined instruments and supplies to prepared procedure trays. | -.11 | -.02 |
| 297 | Obtaining and checking keypunch control card for serial cassette changer as ordered. | -.11 | -.03 |
| 163 | Filling out institutional report form (such as for cancellation) as ordered by MD. | -.11 | -.03 |
| 164 | Filling out patient identification information on labels and forms in anticipation of need or as requested. | -.11 | -.03 |
| 167 | Inspecting and cleaning intensifying screens in cassette holders.* | -.13 | -.04 |
| 267 | Processing exposed Polaroid x-ray film with Polaroid automatic processing equipment.* | -.13 | -.05 |
| 300 | Checking and submitting accumulated patient's treatment and medication check lists for in and out time stamps.* | -.13 | -.05 |
| 137 | Delivering prepared specimens or cultures to lab or incubator.* | -.12 | -.05 |
| 319 | Applying print coater to photographs.* | -.14 | -.05 |
| 288 | Filling out and delivering standard order for food items for department; picking up and placing food for storage.* | -.12 | -.06 |

*See note at end of table.

Table E.1 (continued)

| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[c] |
|---|---|---|---|
| | Level 1 (Aide) continued | | |
| 285 | Checking for presence of emergency supplies in proper locations.* | -.12 | -.05 |
| 184 | Relocking equipment box(es) with breakaway lock.* | -.15 | -.07 |
| 223 | Making up unoccupied bed or stretcher bed.* | -.15 | -.06 |
| 222 | Making photocopies of documents, collating, and stapling.* | -.14 | -.05 |
| 264 | Ordering duplicate copies of forms, records, or documents.* | -.15 | -.08 |

* Tasks marked with asterisk (*) were assigned to this factor based on logic. Low-level tasks load at such low levels on all factors that common sense assignments are appropriate. Every other task was assigned to the factor on which the given task has its highest loading. Tasks on this factor primarily reflect the Run 4 analysis.

Table E.2. FACTOR STRUCTURE OF TASKS: RADIOLOGIC TECHNOLOGY FACTOR



| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[c] |
|---|---|---|---|
| | **Level 4 (Education, Supervision)** | | |
| 82 | Providing clinical training for radiologic technologists or students in radiographic technology. | .22 | x |
| 7 | Observing and evaluating work of radiologic technologists or students in diagnostic radiography, and deciding whether training is needed. | .17 | x |
| | **Level 3 (Technologist)** | | |
| 526 | Taking computerized transverse axial tomographic (C.T.T.) scans of any patient. | .14 | .21 |
| 374 | Taking tomograms of non-infant patient. | .15 | .22 |
| 362 | Taking plain film radiographs of sternum, ribs and/or thoracic viscera of non-infant patient. | .18 | .24 |
| 494 | Taking radiographs of neck, chest of infant patient. | .18 | .23 |
| 511 | Taking catheter thoracic and/or abdominal aortograms of any patient, and/or selective visceral arteriograms (bronchial or abdominal). | .16 | .23 |
| 501 | Taking percutaneous peritoneograms/herniograms of pediatric patient. | .13 | .21 |
| 512 | Taking selective pelvic angiograms of non-pediatric gravid or nongravid female patient. | .12 | .20 |
| 363 | Taking plain film radiographs of abdominal contents of non-infant patient. | .14 | .21 |
| 502 | Taking excretory intravenous inferior vena cavograms and urograms of pediatric patient. | .13 | .21 |
| 509 | Taking spinal cord angiograms of any patient. | .12 | .21 |
| 516 | Taking percutaneous splenoportograms of any patient. | .11 | .19 |

[a] An "x" in column means that task was not included in the run.

[b] Factor VII of 7; combined factor incorporating radiologic technology and quality assurance tasks.

[c] Factor III of 6; radiologic technology tasks.

Note: Tasks are arranged in descending order within levels by difficulty as reflected in the number of skill and knowledge categories required and the scale values at which the categories are required. Factor loadings run from high, positive values, through zero, to negative values (for lower-level tasks).

| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[c] |
|---|---|---|---|
| | Level 3 (Technologist) continued | | |
| 518 | Taking selective pulmonary angiograms or selective angiocardiograms of any patient. | .16 | .22 |
| 387 | Taking intravenous pyelograms and urograms of non-pediatric patient. | .13 | .20 |
| 388 | Taking infusion nephrotomograms of any patient. | .12 | .20 |
| 496 | Taking plain film radiographs of the lower extremities of infant or pediatric patient. | .18 | .23 |
| 519 | Taking percutaneous coronary arteriograms and/or left ventriculograms of any patient. | .12 | .2 |
| 513 | Taking intravenous angiocardiograms of any patient. | .12 | .20 |
| 504 | Taking cerebral angiograms or venograms of any patient. | .12 | .19 |
| 389 | Taking percutaneous antegrade or renal cyst pyelograms of non-infant patient. | .13 | .20 |
| 500 | Taking barium enema, intussusception or defecography radiographs of pediatric patient. | .13 | .21 |
| 499 | Taking upper GI radiographs of pediatric patient. | .13 | .20 |
| 515 | Taking catheter inferior vena cavograms and/or renal or adrenal venograms of non-infant patient. | .11 | .20 |
| 514 | Taking selective thyroid angiograms of any patient. | .10 | .20 |
| 365 | Taking plain film radiographs of the skull and/or face of non-infant patient. | .18 | .25 |
| 375 | Taking sialograms of any patient. | .17 | .22 |
| 506 | Taking positive contrast spinal or posterior fossa myelograms of any patient. | .13 | .20 |
| 508 | Taking air or gas contrast myelograms of any patient. | .13 | .20 |
| 507 | Taking diskograms of any patient. | .13 | .19 |
| 376 | Taking lymphangiograms or lymphadenograms of any patient. | .13 | .21 |
| 495 | Taking plain film radiographs of abdomen of infant patient. | .17 | .20 |
| 5 | Taking pelvic pneumograms and/or hysterosalpingograms of non-pediatric female patient. | .14 | .20 |
| 390 | Taking cystograms and voiding cystourethrograms of any patient. | .13 | .20 |
| 503 | Taking genitograms or fistulograms of any patient for intersex, external fistula or sinus tract examination. | .13 | .19 |
| 378 | Taking bronchograms of a non-pediatric patient. | .13 | .19 |
| 510 | Taking peripheral angiograms of any patient. | .11 | .19 |

| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[c] |
|---|---|---|---|
| | **Level 3 (Technologist) continued** | | |
| 366 | Taking plain film radiographs of the paranasal sinuses of a non-infant patient. | .14 | .21 |
| 505 | Taking pneumoencephalograms or brain ventriculograms of any patient. | .12 | .19 |
| 377 | Taking positive contrast arthrograms (especially of knee) of any patient. | .13 | .19 |
| 517 | Taking selective subclavian arteriograms of non-pediatric patient for thoracic outlet syndrome evaluation. | .12 | .19 |
| 380 | Providing technical assistance for laryngography or cleft palate study of any patient (or any similar fluoroscopic examination including spot filming and/or cineradiography). | .12 | .17 |
| 360 | Taking plain film radiographs of pelvis, hips and/or upper femora of non-infant patient. | .18 | .23 |
| 361 | Taking plain film radiographs of vertebral column of non-infant patient. | .18 | .23 |
| 492 | Taking plain film radiographs of vertebral column of infant patient. | .17 | .22 |
| 493 | Taking plain film radiographs of the upper extremities of infant patient. | .17 | .22 |
| 491 | Taking plain film radiographs of the skull of infant patient. | .17 | .22 |
| 463 | Taking retrograde pyelograms and ureterograms of non-pediatric patient. | .13 | .19 |
| 355 | Taking plain film radiographs of fingers, hand(s) or wrist(s) of non-infant patient. | .18 | .23 |
| 356 | Taking plain film radiographs of forearm and/or elbow joint of non-infant patient. | .18 | .23 |
| 357 | Taking plain film radiographs of humerus and/or shoulder girdle of non-infant patient. | .18 | .23 |
| 358 | Taking plain film radiographs of toes, foot and/or ankle joint of non-pediatric patient. | .18 | .23 |
| 359 | Taking plain film radiographs of leg(s), knee(s) and/or femur(s), of non-infant patient. | .18 | .23 |
| 364 | Taking radiographs of anterior portion of the neck of non-infant patient. | .13 | .20 |
| 383 | Taking barium enema radiographs of non-pediatric patient. | .13 | .19 |
| 385 | Taking intravenous cholangiograms and cholecystograms of non-infant patient. | .12 | .16 |
| 379 | Carrying out radiologic technology for bronchoscopy or needle lung biopsy of a non-pediatric patient. | .13 | .18 |

| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[c] |
|---|---|---|---|
| | **Level 3 (Technologist) continued** | | |
| 368 | Taking mammograms (radiography or xeroradiography) of non-infant patient. | .13 | .19 |
| 381 | Taking upper GI radiographs of non-pediatric patient. | .13 | .19 |
| 382 | Taking small intestine intubation radiographs of a non-pediatric patient. | .13 | .18 |
| 498 | Taking bronchograms of a pediatric patient. | .12 | .17 |
| 386 | Taking percutaneous or T-tube cholangiograms of non-infant patient. | .12 | .17 |
| 353 | Participating in meeting of diagnostic x-ray department technologists. | .09 | x |
| 367 | Taking preliminary localization radiographs of foreign bodies in orbit or eye of non-infant patient. | .13 | .18 |
| 497 | Taking radiographs for choanal atresia study of infant patient. | .12 | .15 |
| 384 | Taking oral cholecystograms and cholangiograms of non-infant patient. | .11 | .14 |
| 466 | Taking radiographs of a pregnant patient's abdomen for fetography, amniography, placentography. | .12 | .16 |
| 467 | Taking radiographs of a pregnant patient's uterus for intrauterine transfusion. | .13 | .17 |
| 468 | Taking radiographs of a pregnant patient's pelvis for Colcher-Sussman pelvimetry. | .12 | .17 |
| 370 | Taking operative orthopedic radiographs of any patient (such as in hip pinning). | .13 | .10 |
| 371 | Taking operative cholangiograms, pancreatograms or similar operative radiographs of any patient. | .11 | .04 |
| 464 | Providing technical assistance for an examination of any patient requiring fluoroscopic control and spot filming. | .08 | .03 |
| 81 | Providing technical quality review of "plain film" radiographs.* | .04 | -.04 |
| 373 | Taking operating room radiographs for opaque foreign body search.* | .09 | -.01 |

* See note at end of table.

| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[c] |
|---|---|---|---|
| | Level 3 (Technologist) continued | | |
| 372 | Taking intravisceral or isolated operating room radiographs of any patient.* | .09 | -.04 |
| 369 | Preparing, transporting, setting up and returning mobile portable radiography equipment for bedside radiography.* | .03 | -.04 |
| 280 | Participating in monitoring of personal exposure to radiation by periodically turning in and replacing film strip in badge worn by performer.* | -.02 | -.12 |

*Each task was assigned to the factor on which it has its highest loading, reflecting primarily the Run 4 analysis. Tasks marked with an asterisk (*) were assigned on the basis of logic. Tasks 280, 369, 372 and 81 load higher on the quality assurance factor at level 2; however, the knowledge categories required are more in keeping with those needed for the tasks in this factor. Task 280 is included on three factors, since it deals with protection of the performer.

Task 309, "Calling and participating as supervisor in meeting of subordinates in department," loads on this factor at level 3, but should have been scaled more appropriately to refect level 4 knowledge or should not have been scaled for technologist knowledge and been grouped as a generic task with non-factor A, administrative tasks.

Table E.3 FACTOR STRUCTURE OF TASKS: PATIENT AND EMERGENCY CARE FACTOR



| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[c] |
|---|---|---|---|
| | **Level 4 (Education, Emergency Care)** | | |
| 158 | Informally observing and evaluating patient care work of nursing and technologist staff in diagnostic radiography, and deciding whether training is needed. | .27 | x |
| 305 | Providing informal clinical training in patient care for non-MD personnel in diagnostic radiography. | .28 | x |
| 77 | Providing emergency care for any patient having adverse reaction to radiographic contrast medium, procedures, or accident. | .20 | .22 |
| 19 | Administering test (intravenous) to any patient for allergy to iodine based contrast medium. | .11 | .14 |
| | **Level 2 (Technician)*** | | |
| 299 | Administering subcutaneous or intramuscular injection for any patient according to MD's orders. | .04 | .23 |
| 133 | Administering subcutaneous or intramuscular injection for any patient according to MD's orders after having quantity checked. | .02 | .22 |
| 296 | Providing first aid in x-ray department emergency. | .15 | .17 |
| 33 | Removing any patient's sutures. | -.02 | .02 |
| 298 | Administering medication orally to any patient according to MD's orders. | -.05 | .13 |
| 156 | Irrigating, cleaning, dressing or redressing any patient's wound, burn, or opening for catheter as ordered. | -.02 | -.01 |
| 181 | Catheterizing any male or female patient's urethra with retention balloon catheter.* | -.04 | -.03 |

[a] An "x" in column means that task was not included in the run.

[b] Factor IV of 7; patient and emergency care.

[c] Factor IV of 6; patient and emergency care.

* See note at end of table.

Note: Tasks are arranged in descending order within levels by difficulty as reflected in the number of skill and knowledge categories required and the scale values at which the categories are required. Factor loadings run from high, positive values, through zero, to negative values (for lower-level tasks).

Table E.3 (continued)

| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1 | Run 4[c] |
|---|---|---|---|
| | **Level 2 (Technician)* continued** | | |
| 143 | Catheterizing any female urethra as ordered. | -.06 | -.03 |
| 198 | Administering medication orally to any patient according to MD's orders after having quantity checked. | -.08 | .11 |
| 65 | Preparing specimens such as extravascular body fluids, washings, cell and/or tissue biopsies for transportation to laboratory.* | -.07 | -.04 |
| 308 | Setting up and monitoring any patient's electrocardiogram during special procedure.* | -.05 | -.05 |
| 522 | Applying pressure dressing to arterial or venous puncture site. | -.07 | -.03 |
| 18 | Drawing blood from any non-pediatric patient's vein on orders.* | -.07 | -.04 |
| 185 | Administering oxygen from portable or piped outlet unit using oronasal or nasal mask according to MD's orders.* | -.10 | -.04 |
| 182 | Setting up and using suction machine to clear airway or to assist with gastric lavage.* | -.05 | -.05 |
| 243 | Restraining any patient.* | -.08 | -.06 |
| 280 | Participating in monitoring of personal exposure to radiation by periodically turning in and replacing film strip in badge worn by performer.* | -.11 | -.10 |
| | **Level 1 (Aide)*** | | |
| 520 | Preparing any patient and attaching electrodes for electrocardiogram monitoring.* | -.08 | -.06 |
| 295 | Participating in meeting of nursing personnel in x-ray department. | -.08 | x |
| 283 | On orders, deciding whether wound of any patient needing change of dressing needs attention of RN; changing simple dry dressing or reinforcing wet dressing. | -.08 | -.03 |
| 166 | Using isolation and decontamination techniques to prepare examination or treatment room or area and clean up afterwards for patient with infectious or communicable condition.* | -.08 | -.06 |

* See note at end of table.

Table E.3 (continued)



| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[c] |
|---|---|---|---|
| | Level 1 (Aide) continued | | |
| 290 | Changing any patient's colostomy bag on orders.* | -.09 | -.05 |
| 190 | Assisting patient to or from wheelchair, stretcher, bed, or table and/or transporting patient to designated area.* | -.08 | -.06 |
| 193 | Having any patient and materials prepared for special procedure and readying patient for examination.* | -.08 | -.07 |
| 262 | Taking an electrocardiogram of any patient as ordered or determined.* | -.11 | -.08 |
| 73 | Reassuring any patient and/or accompanying adult about x-ray and/or fluoroscopy procedures.* | -.11 | -.09 |
| 521 | Applying digital or manual pressure to any patient's arterial or venous puncture site as ordered.* | -.08 | -.05 |
| 490 | Mummying or wrapping an infant or young pediatric patient.* | -.08 | -.06 |
| 138 | Reporting observed symptoms and concerns of any patient to physician or staff member.* | -.11 | -.08 |
| 153 | Assisting physician or co-worker in special examination or treatment procedures.* | -.09 | -.06 |
| 282 | Escorting adult out-patients to and/or from dressing rooms, treatment rooms and/or waiting areas.* | -.11 | -.07 |
| 199 | Taking and recording vital signs (temperature, pulse, respiration and blood pressure) of any patient.* | -.11 | -.08 |
| 287 | On orders, placing order for specific dietetic meal; picking up, delivering, and feeding patient if so decided.* | -.10 | -.06 |
| 303 | Arranging, measuring and recording food intake and excretory output as ordered.* | -.12 | -.08 |
| 113 | Giving any patient general reassurance.* | -.12 | -.09 |
| 302 | Placing or making call and delivering non-medical message at patient or co-worker's request.* | -.10 | -.06 |
| 278 | Checking on reasons for nonappearance of in-patients for examinations or treatment.* | -.14 | -.10 |
| 74 | Explaining to any out-patient or accompanying adult proper at-home procedures to follow prior to coming for radiographic or fluoroscopic examination.* | -.14 | -.11 |

* See note at end of table.

Table E.3 (continued)

| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[c] |
|---|---|---|---|
| | Level 1 (Aide) continued | | |
| 271 | Deciding whether to call staff person to evaluate whether unusual EKG reading is artifact, or calling physician in case of serious patient distress.* | -.13 | -.08 |
| 289 | Bottle feeding a baby with pre-prepared formula.* | -.14 | -.10 |
| 301 | Diapering a baby.* | -.13 | -.09 |
| 155 | Obtaining urine specimen on orders.* | -.12 | -.09 |
| 292 | Obtaining and examining fresh stool from any patient and reporting unusual or suspicious appearance, on orders.* | -.13 | -.09 |
| 98 | Obtaining a clean catch urine specimen from any patient and preparing for laboratory.* | -.13 | -.07 |
| 281 | Checking in-patients' identity against patients' treatment and medication check lists; stamping arrival and departure times; attaching cards to patients indicating special conditions.* | -.15 | -.09 |
| 291 | Taking and reporting temperature of any non-pediatric patient with oral thermometer on orders.* | -.16 | -.09 |
| 279 | Notifying ward or floor personnel to ready and transport in-patients who are scheduled for specific procedures at specific times.* | -.15 | -.09 |

* Tasks marked with asterisk (*) were assigned to this factor on the basis of logic. Low-level tasks are assigned on the basis of content, since they load at low levels on all factors. Every other task was assigned to the factor on which the task has its highest loading. Tasks in this factor primarily reflect the Run 4 analysis.

Task 280 is included in three factors, since it deals with protection of the performer.

Tasks 299, 133 and 296 could have been assigned to a level 3 grouping, the technologist level, which is not identified for this factor. That would correspond to the RN level. We did not feel that the three tasks warranted grouping at a separate level. An individual trained at level 2 in this factor would require the additional training for these three tasks involving a knowledge of drugs and injection procedures, and special permission to function in states where injections require the RN license.

Table E.4. FACTOR STRUCTURE OF TASKS: ADMINISTRATIVE TASKS (NON-FACTOR A)[a]



| Task Code | Abbreviated Task Name and Job Level | Factor Loading[b] Run 1[c] |
|---|---|---|
| | **Level 4 (Supervision)** | |
| 309[d] | Calling and participating as supervisor in meeting of subordinates in department.* | -.04 |
| 307 | Conducting a private personnel meeting with subordinate. | -.03 |
| 306 | Formally evaluating subordinates' work by filling out descriptive and/or rating-scale evaluation forms. | -.04 |
| | **Level 3 (Technologist)** | |
| 293 | Attending personal meeting with supervisor on functioning or personal, work-related problems. | -.04 |
| 186 | Orienting new staff member(s) to departmental standard operating and administrative procedures, floor plan, location of equipment and supplies, record keeping.* | -.05 |
| 131 | Making assignments of staff to work areas, procedures, and/or MD's and/or vacations and lunch hours.* | -.06 |
| 272 | Preparing and adjusting schedules for patient procedures.* | -.07 |

[a] This group of tasks is referred to as non-factor A, since this does not constitute a separate task factor in the Run 4 six-factor solution, and the tasks would rarely constitute a separate job.

[b] Tasks are arranged in descending order within levels by difficulty as reflected in the number of skill and knowledge categories required and the scale values at which the categories are required. Factor loadings run from high, positive values, through zero, to negative values (for lower-level tasks or tasks that do not load at high levels on the factor).

[c] In the seven-factor solution of Run 1, this group of tasks primarily have their highest loading on Factor III, which is an ambulatory care examinations, counseling, administrative and conference factor. The Run 1 loadings are listed, but this group of tasks is treated as a separate non-factor cluster in the Run 4 solution.

[d] Task 309 loads on the radiologic technology factor, but should have been scaled as a generic administrative task. It belongs with this group.

* See note at end of table.

| Task Code | Abbreviated Task Name and Job Level | Factor Loading[b] Run 1[c] |
|---|---|---|
| | **Level 3 (Technologist) continued** | |
| 76 | Checking supplies and ordering non-drug materials needed by department* | -.06 |
| 165 | Keeping attendance records and recording or reporting excessive lateness and/or absenteeism.* | -.06 |
| 277 | Assigning scheduled patients to procedure rooms in appropriate order.* | -.06 |
| 294 | Assigning subordinate and explaining assignment to transport patient, obtain materials or documents, or assist co-worker.* | -.06 |
| 129 | Checking supply and ordering non-narcotic medicinals needed by department.* | -.07 |
| 128 | Checking supply of narcotics or regulated drugs (or witnessing count); reordering, picking up, and restocking.* | -.06 |
| 132 | Requesting repair, replacement or other services of another hospital department orally and/or filling out requisition.* | -.07 |

* Tasks marked with an asterisk (*) were arbitrarily assigned to non-factor A. All other tasks loaded highest on Factor III of Run 1 (which includes administration), and were assigned to non-factor A for the Run 4 solution.

Table E.5. FACTOR STRUCTURE OF TASKS: NON-NEUROLOGIC RADIOLOGY FACTOR



| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[b] |
|---|---|---|---|
| | Level 6 (Specialized Advanced Professional) | | |
| 441 | Deciding on type of pediatric radiographic examination(s) to order for pediatric patient in consultation with referring physician and/or pediatric specialist. | .64 | 1.01 |
| 459 | Participating in meetings of radiologists, surgeons and pediatricians to discuss new developments, cases of interest, and case problems in the field of pediatric surgery and radiology. | .64 | x |
| 460 | Providing clinical training for radiology residents in pediatric radiography. | .64 | x |
| 461 | Planning and presenting lectures or case conferences on pediatric radiology for radiology residents. | .63 | x |
| 458 | Reading, interpreting and making recommendations on radiographic and related studies of pediatric patients. | .60 | .92 |
| 469 | Deciding on type of non-neurologic angiography procedure to order for any patient in consultation with referring physician, surgeon, and/or other specialist. | .60 | .84 |
| 486 | Providing clinical training for radiology resident in non-neurologic angiography. | .60 | x |
| 485 | Participating in meetings of angiographers, vascular surgeons and cardiologists to discuss new developments, cases of interest, and case problems in the field of angiography, vascular and cardiovascular surgery. | .58 | x |
| 314 | Deciding whether to order non-neurologic computerized transverse axial tomography for any patient and/or alternative studies in consultation with referring physician. | .57 | .74 |

[a] An "x" in column means that task was not included in the run.

[b] Factor I of 7 and I of 6; non-neurologic radiologist tasks.

Note: Tasks are arranged in descending order based on Run 1 factor loadings. The loadings do not necessarily imply order of difficulty, since the loadings reflect the skills and knowledges whose co-variations explain the factor structure. Assignment to this factor combines Run 1 and Run 4 solutions. Factor loadings run from high, positive values, through zero, to negative values (for lower-level tasks).

| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[b] |
|---|---|---|---|
| | Level 8 (Specialized Advanced Professional) continued | | |
| 352 | Participating in meetings of radiologists, surgeons and pathologists to discuss new developments, cases of interest and case problems in the field of gastrointestinal and biliary surgery and radiology. | .56 | x |
| 347 | Providing clinical training for radiology residents in radiographic study of the gastrointestinal and biliary tracts. | .56 | x |
| 348 | Planning and presenting lectures or case conferences on gastrointestinal and biliary tract radiology for radiology residents. | .56 | x |
| 473 | Conducting catheter abdominal aortography and/or selective visceral arteriography of any patient. | .56 | .75 |
| 488 | Directing computerized transverse axial tomography of the body of any patient. | .55 | .70 |
| 477 | Conducting catheter pulmonary angiography of any patient. | .55 | .68 |
| 474 | Conducting percutaneous translumbar abdominal aortography of any patient. | .54 | .74 |
| 311 | Deciding on type of urographic procedure(s) to order for any patient in consultation with referring physician and/or specialists. | .54 | .70 |
| 470 | Conducting peripheral arteriography of any patient by percutaneous selective catheterization or direct needle puncture. | .54 | .69 |
| 472 | Conducting catheter thoracic aortography of any patient. | .54 | .67 |
| 483 | Conducting percutaneous coronary arteriography and/or left ventriculography of any patient. | .54 | .66 |
| 337 | Participating in meetings with pulmonary specialists, surgeons and pathologists to discuss new developments, cases of interest and case problems in pulmonary medicine, surgical pathology and thoracic surgery. | .53 | x |
| 416 | Providing clinical training for radiology residents in radiographic procedures of lungs, bronchi, trachea and/or larynx. | .53 | x |
| 415 | Planning and presenting lectures or case conferences on pulmonary, tracheal, bronchial and laryngeal radiology for radiology residents. | .53 | x |
| 471 | Conducting ascending or descending venography of lower extremities of any patient by direct needle puncture. | .53 | .70 |

Table E.5 (continued)

| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[b] |
|---|---|---|---|
| | Level 8 (Specialized Advanced Professional) continued | | |
| 331 | Deciding whether to order non-neurologic tomography for any patient or alternative studies, and recommending technique in consultation with referring physician. | .53 | .67 |
| 409 | Deciding on type of respiratory radiographic examination(s) to order for any patient in consultation with referring physician and/or specialists. | .52 | .67 |
| 478 | Conducting selective bronchial arteriography of any patient. | .52 | .66 |
| 481 | Conducting intravenous angiocardiography of any patient by percutaneous selective catheterization or direct needle puncture. | .52 | .63 |
| 482 | Conducting catheter vena cavography and/or selective renal or adrenal venography of any non-infant patient. | .52 | .62 |
| 318 | Providing clinical training for radiology residents in urographic procedures. | .51 | x |
| 424 | Providing clinical training for radiology residents in obstetrical and gynecological radiographic procedures. | .51 | x |
| 438 | Providing clinical training for radiology residents in orthopedic radiology and arthrography. | .51 | x |
| 346 | Reading, interpreting and making recommendations on radiographs of gastrointestinal and/or biliary tracts. | .51 | .76 |
| 479 | Conducting selective thyroid angiography of any patient. | .51 | .66 |
| 68 | Preparing research design in clinical diagnostic radiology; supervising research; analyzing, evaluating results; and preparing report. | .51 | .60 |
| 323 | Participating in meetings of radiologists, urologists and nephrologists to discuss new developments, cases of interest, and case problems in the fields of urology and urography. | .50 | x |
| 423 | Participating in meetings of radiologists, obstetricians, and gynecologists to discuss new developments, cases of interest and case problems of mutual interest. | .50 | x |
| 425 | Planning and presenting lectures or case conferences on obstetrical and gynecological radiology for radiology residents. | .50 | x |
| 336 | Providing clinical training for radiology residents in lymphangiography procedures. | .50 | x |
| 435 | Providing clinical training for radiology residents in ear, nose and throat radiography and sialography. | .50 | x |

Table E.5 (continued)



| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[b] |
|---|---|---|---|
| | Level 8 (Specialized Advanced Professional) continued | | |
| 446 | Conducting radiography of external fistula or sinus tract of any patient. | .50 | .72 |
| 48 | Reading, interpreting and making recommendations on non-neurological computerized transverse axial tomographic scans of the body. | .50 | .66 |
| 475 | Conducting percutaneous splenoportography of any patient. | .50 | .66 |
| 332 | Reading, interpreting and making recommendations on non-neurological tomograms. | .50 | .65 |
| 476 | Conducting selective pelvic arteriography of non-pediatric gravid or nongravid female patient. | .50 | .64 |
| 328 | Deciding whether to order lymphangiography of any patient or alternative studies and recommending technique, in consultation with referring physician. | .50 | .62 |
| 339 | Deciding on type of gastrointestinal and/or biliary radiographic examinations to order for any patient in consultation with referring physician and/or specialists. | .49 | .74 |
| 317 | Reading, interpreting and making recommendations on urographic materials. | .49 | .61 |
| 66 | Formulating a problem for clinical research in diagnostic radiology. | .49 | .60 |
| 67 | Conducting literature review for clinical research problem in diagnostic radiology. | .48 | .59 |
| 462 | Planning and presenting lectures on pediatric radiology for medical students. | .47 | x |
| 6 | Reading, interpreting and making recommendations on routine radiographic materials. | .47 | .60 |
| 480 | Conducting selective subclavian arteriography of any non-pediatric patient to evaluate thoracic outlet syndrome. | .47 | .59 |
| 324 | Participating in meetings of physicians involved with arthritis to discuss new developments, cases of interest and case problems in the field. | .46 | x |
| 345 | Conducting T-tube cholangiography of any patient. | .46 | .68 |
| 329 | Conducting lymphangiography of any patient. | .46 | .60 |
| 436 | Conducting positive contrast arthrography (especially of knee) of any patient. | .46 | .59 |
| 313 | Directing nephrotomography of any patient. | .46 | .58 |
| 315 | Performing renal cyst puncture and conducting related radiography of any patient. | .46 | .56 |
| 4 | Conducting pelvic pneumography and/or pangynecography of non-infant female patient. | .46 | .55 |

| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[b] |
|---|---|---|---|
| | Level 8 (Specialized Advanced Professional) continued | | |
| 452 | Conducting esophageal radiography of pediatric patient. | .46 | .69 |
| 344 | Conducting intravenous cholangiography and cholecystography (IVC) of any non-infant patient. | .45 | .67 |
| 443 | Conducting bronchography of pediatric patient in consultation with pediatrician(s) and anesthesiologist. | .45 | .61 |
| 412 | Conducting laryngography of any non-pediatric patient. | .45 | .61 |
| 411 | Conducting bronchography of any non-pediatric patient. | .45 | .59 |
| 4[illegible] | Reading, interpreting and making recommendations on orthopedic radiographs and/or arthrograms and related studies of bones and joints. | .45 | .58 |
| 421 | Deciding on type of gynecological radiographic procedures to order for non-pediatric female patient in consultation with referring physician. | .45 | .56 |
| 330 | Reading, interpreting and making recommendations on lymphangiograms. | .45 | .55 |
| 338 | Participating in meetings of physicians involved with plastic surgery to discuss new developments, cases of interest, and case problems in the field. | .44 | x |
| 448 | Conducting percutaneous peritoneography/inguinal herniography of pediatric patient. | .44 | .66 |
| 455 | Conducting defecography of pediatric patient. | .44 | .66 |
| 484 | Reading, interpreting and making recommendations on non-neurologic angiographic and related studies. | .44 | .65 |
| 343 | Conducting percutaneous (transhepatic) cholangiography of any non-pediatric patient. | .44 | .64 |
| 342 | Evaluating oral cholecystograms or oral cholangiograms; conducting fluoroscopy and/or post-fatty meal, post-evacuation study of any non-infant patient involved if so decided. | .44 | .64 |
| 2 | Conducting a radiographic barium swallow study of esophagus of any non-pediatric patient. | .44 | .64 |
| 433 | Conducting sialography of any patient. | .44 | .61 |
| 444 | Conducting intravenous excretory urography (IVP) and inferior vena cavography of pediatric patient. | .44 | .60 |
| 426 | Conducting percutaneous antegrade pyelography of any non-pediatric patient. | .44 | .55 |
| 487 | Planning and presenting lectures or case conferences on non-neurologic angiography for radiology residents. | .43 | x |
| 453 | Conducting radiographic barium study of upper gastrointestinal tract of pediatric patient. | .43 | .6[illegible] |
| 341 | Conducting small bowel enema radiographic study of any non-pediatric patient. | .43 | .64 |

Table E.5 (continued)



| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[b] |
|---|---|---|---|
| | Level 8 (Specialized Advanced Professional) continued | | |
| 434 | Reading, interpreting and making recommendations on sialography and related materials. | .43 | .59 |
| 312 | Conducting intravenous pyelography (IVP) examination of any non-pediatric patient. | .43 | .56 |
| 5 | Conducting hysterography or hysterosalpingography of a non-pediatric female patient. | .43 | .53 |
| 410 | Conducting bronchoscopy and related biopsy and secretion sampling of any non-pediatric patient. | .43 | .53 |
| 456 | Conducting diagnosis and hydrostatic reduction of intussuception of pediatric patient. | .42 | .65 |
| 340 | Conducting hypotonic duodenography of any non-pediatric patient. | .42 | .61 |
| 395 | Conducting a radiographic air contrast study of stomach of any non-pediatric patient. | .42 | .61 |
| 445 | Conducting retrograde voiding cystourethrography of pediatric patient. | .42 | .58 |
| 454 | Conducting a radiographic barium enema study of lower gastrointestinal tract of pediatric patient. | .41 | .64 |
| 3 | Conducting a radiographic barium study of upper gastrointestinal tract of any non-pediatric patient. | .41 | .62 |
| 1 | Conducting a radiographic barium enema study of lower gastrointestinal tract of any non-pediatric patient. | .41 | .62 |
| 447 | Conducting vaginography of pediatric patient for intersex condition. | .41 | .58 |
| 413 | Conducting aspiration or tissue needle biopsy of the lung of any non-pediatric patient. | .41 | .51 |
| 392 | Planning and presenting cases and/or related lectures on diagnostic radiology and pathology to pathologists, radiologists and residents. | .40 | x |
| 450 | Evaluating plain films of pediatric gastrointestinal tract to localize obstructions and/or foreign bodies. | .40 | .59 |
| 418 | Deciding on type of obstetrical radiographic procedures to order for pregnant patient in consultation with referring obstetrician. | .40 | .52 |
| 420 | Conducting intrauterine fetal radiography for intrauterine transfusion in consultation with obstetrician. | .39 | .50 |
| 325 | Participating in meetings of radiologists, surgeons and pathologists to discuss new developments, cases of interest and case problems in the fields of surgery and radiology. | .38 | x |
| 451 | Removing foreign object from pediatric upper esophagus under fluoroscopic control. | .38 | .54 |

| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[b] |
|---|---|---|---|
| | **Level 8 (Specialized Advanced Professional) continued** | | |
| 449 | Reading and interpreting radiographs for bone-age study. | .38 | .51 |
| 394 | Comparing prior radiographic diagnoses with later pathology and/or autopsy reports and reporting discrepancies to appropriate radiologists. | .36 | .51 |
| 442 | Conducting choanal radiography of pediatric patient. | .36 | .46 |
| 422 | Reading, interpreting and making recommendations on obstetrical and/or gynecological radiographic studies and related materials. | .35 | .41 |
| 349 | Planning and presenting lectures on gastrointestinal and biliary tract radiology for medical students. | .33 | x |
| 393 | Reviewing and selecting current and/or inactive radiographs for instructional use. | .33 | .48 |
| 391 | Selecting and assembling radiographs and related case history information for use in case conference in diagnostic radiology. | .33 | .47 |
| 414 | Reading, interpreting and making recommendations on radiographic materials involving bronchi, lungs, trachea and/or larynx. | .33 | .41 |
| 320 | Planning and presenting lectures on assigned aspects of radiology for medical students. | .32 | x |
| 20 | Directing respiratory tract tomography. | .31 | .38 |
| 417 | Planning and presenting lectures on pulmonary, bronchial, tracheal and laryngeal radiography for medical students. | .19 | x |
| 457 | Conducting fluoroscopic inspiration-expiration examination of pediatric patient. | .12 | .16 |
| 406 | Providing clinical training for radiology residents in mammography procedures. | .11 | x |
| 335 | Reading, interpreting and making recommendations on cineradiographic cleft palate studies. | .11 | .17 |
| 334 | Conducting a fluoroscopic and cineradiographic cleft palate study of any patient. | .10 | .13 |
| 333 | Deciding on and scheduling cleft palate radiological study for any patient. | .09 | .11 |
| 310 | Selecting gastrointestinal and biliary tract radiographic materials for use in case conference or lecture presentations or for inclusion in library. | .07 | .15 |
| 403 | Reading, interpreting and making recommendations on mammographic materials. | .07 | .07 |
| 402 | Conducting mammographic examination of any patient's breasts. | .06 | .06 |

Table E.5 (continued)



| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[b] |
|---|---|---|---|
| | Level 8 (Specialized Advanced Professional) continued | | |
| 419 | Calculating and interpreting radiographic pelvimetry using Colcher-Sussman technique. | .00 | -.05 |
| 351 | Deciding on whether to enter suggested radiographs of gastrointestinal and biliary tracts into log book based on quality and educational value. | -.03 | .03 |
| 322 | Deciding on diagnostic radiology library acquisitions of books, journals and radiographic materials; coding library acquisitions. | -.10 | -.16 |
| 326 | Participating in diagnostic radiology departmental meeting. | -.13 | x |
| 316 | Assisting in renal biopsy of any patient by using fluoroscopy to place biopsy needle. | -.13 | -.22 |
| 350 | Conducting counseling on professional or personal problems with residents in radiology. | -.16 | -.25 |
| 321 | Participating in radiologists meeting to arrive at overall clinical and academic assessments of residents in radiology. | -.19 | x |
| 439 | Ordering or approving changes in technical factor selector settings to compensate for a change in quality of x-ray machine output. | -.21 | -.30 |
| 327 | Participating in monitoring of personal exposure to radiation by periodically turning in and replacing film strip in badge; evaluating posted exposure listings. | -.23 | -.31 |

Table E.6. FACTOR STRUCTURE OF TASKS: NEURORADIOLOGY FACTOR



| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[b] |
|---|---|---|---|
| | **Level 8 (Specialized Advanced Professional)** | | |
| 405 | Providing clinical training for radiology residents in neuroradiology procedures. | .60 | x |
| 408 | Participating in meetings of radiologists, surgeons and neurologists to discuss new developments, cases of interest and case problems in the fields of neurology, surgery and neuroradiology. | .59 | x |
| 407 | Planning and presenting lectures or case conferences on neuroradiology for radiology residents. | .59 | x |
| 404 | Reading, interpreting and making recommendations on neuroradiographic materials. | .51 | 1.48 |
| 396 | Deciding on type of neuroradiologic procedure(s) to order for any patient in consultation with referring physician and/or neurologist. | .56 | 1.45 |
| 397 | Conducting cerebral angiography of any patient. | .54 | 1.38 |
| 427 | Conducting retrograde venography of the internal jugular veins, posterior fossa dural sinus system and/or orbit of any patient. | .53 | 1.36 |
| 428 | Conducting orbital and/or cavernous sinus venography of any patient by frontal vein route. | .52 | 1.35 |
| 430 | Conducting positive contrast posterior fossa myelography of any patient. | .49 | 1.34 |
| 399 | Cooperating with surgeon in conducting brain ventriculography of any patient. | .46 | 1.34 |
| 398 | Conducting pneumoencephalography of any patient. | .34 | 1.33 |
| 440 | Directing computerized transverse axial tomography of the skull and brain of any patient. | .50 | 1.10 |
| 429 | Conducting selective spinal cord angiography of any patient. | .39 | .85 |
| 400 | Conducting positive contrast myelography of any patient. | .38 | .80 |
| 401 | Conducting air contrast myelography of any patient. | .30 | .76 |

[a] An "x" in column means that task was not included in the run.

[b] Factor II of 7 and II of 6; neuroradiologist tasks.

Note: Tasks are arranged in descending order based on Run 4 factor loadings. The loadings do not necessarily imply order of difficulty, since the loadings reflect the skills and knowledges whose co-variations explain the factor structure. Assignment to this factor combines Run 1 and Run 4 solutions. Factor loadings run from high, positive values, through zero, to negative values (for lower-level tasks).

Table E.6 (continued)



| Task Code | Abbreviated Task Name and Job Level | Factor Loading[a] Run 1[b] | Run 4[b] |
|---|---|---|---|
| | Level 8 (Specialized Advanced Professional) continued | | |
| 431 | Conducting discography of any patient. | .29 | .63 |
| 432 | Directing skull tomography of any patient. | .00 | .05 |
| 327 | Participating in monitoring of personal exposure to radiation by periodically turning in and replacing film strip in badge; evaluating posted exposure listings. | -.05 | -.06 |
| 439 | Ordering or approving changes in technical factor selector settings to compensate for a change in quality of x-ray machine output. | -.06 | -.06 |
| 326 | Participating in diagnostic radiology departmental meeting. | -.10 | x |

Table E.7. FACTOR STRUCTURE OF TASKS: OBSTETRICS-GYNECOLOGY RADIOLOGY FACTOR



| Task Code | Abbreviated Task Name and Job Level | Factor Loadings[a] Run 1[b] | Run 4[b] |
|---|---|---|---|
| | Level 8 (Specialized Advanced Professional) | | |
| 425 | Planning and presenting lectures or case conferences on obstetrical and gynecological radiology for radiology residents. | .33 | x |
| 423 | Participating in meetings of radiologists, obstetricians, and gynecologists to discuss new developments, cases of interest and case problems of mutual interest. | .33 | x |
| 424 | Providing clinical training for radiology residents in obstetrical and gynecological radiographic procedures. | .32 | x |
| 422 | Reading, interpreting, and making recommendations on obstetrical and/or gynecological radiographic studies and related material. | .27 | .85 |
| 421 | Deciding on type of gynecological radiographic procedures to order for non-pediatric female patient in consultation with referring physician. | .27 | .78 |
| 418 | Deciding on type of obstetrical radiographic procedures to order for pregnant patient in consultation with referring obstetrician. | .29 | .62 |
| 420 | Conducting intrauterine fetal radiography for intrauterine transfusion in consultation with obstetrician. | .29 | .62 |
| 5 | Conducting hysterography or hysterosalpingography of a non-pediatric female patient. | .20 | .62 |
| 4 | Conducting pelvic pneumography and/or pangynecography of non-infant female patient. | .21 | .61 |
| 419 | Calculating and interpreting radiographic pelvimetry using Colcher-Sussman technique. | .15 | .51 |
| 406 | Providing clinical training for radiology residents in mammography procedures. | .09 | x |
| 403 | Reading, interpreting and making recommendations on mammographic materials. | .05 | .33 |
| 402 | Conducting mammographic examination of any patient's breasts. | .05 | .32 |

[a] An "x" in column means that task was not included in the run.

[b] Factor V of 7 and V of 6; obstetrics-gynecology radiologist tasks.

Note: Tasks are arranged in descending order based on Run 4 factor loadings. The loadings do not necessarily imply order of difficulty, since the loadings reflect the skills and knowledges whose co-variations explain the factor structure. Assignment to this factor combines Run 1 and Run 4 solutions. Factor loadings run from high, positive values, through zero, to negative values (for lower-level tasks).

| Task Code | Abbreviated Task Name and Job Level | Factor Loadings[a] Run 1[b] | Run 4[b] |
|---|---|---|---|
| | Level 8 (Specialized Advanced Professional) continued | | |
| 326 | Participating in diagnostic radiology departmental meeting. | -.03 | x |
| 439 | Ordering or approving changes in technical factor selector settings to compensate for a change in quality of x-ray machine output. | -.05 | -.02 |
| 327 | Participating in monitoring of personal exposure to radiation by periodically turning in and replacing film strip in badge; evaluating posted exposure listings. | -.06 | -.03 |

Note: This is a secondary factor, since most tasks in this factor have a higher loading on Factor I in the Run 1 solution. Most tasks have a higher loading on this factor than on Factor I in the Run 4 solution.